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PROBLEMS OF MALARIA IN THE ADEN PROTECTORATE
(REPORT ON A VISIT)

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CONTENTS

BACKGROUND INFORMATION

General Description of the Country[1]

Geography (see Map 1). The Aden Protectorates cover an area of 112 000 square miles (290 000 km^2) situated in the south-west corner of the Arabian Peninsula. They are bounded on the south by the Indian Ocean and the small area of the Aden Colony (latitude 12° 47' N, longitude 45° 10' E); on the east by the Sultanate of Muscat and Oman; to the north by the great Arabian desert where the border has not been completely defined; and to the west lies the Republic of the Yemen. The coast line is 750 miles (1200 km) long and the depth of the country varies from 100 miles (160 km) in the west to about 300 miles (480 km) in the east.

The Protectorates are divided administratively into two parts; the Western Aden Protectorate and the Eastern Aden Protectorate (known as WAP and EAP respectively). The area of the WAP is 30 000 square miles (77 700 km^2). The administration is also responsible for the islands of Perim, Socotra and Kamaran.

The topography of the Protectorates differs slightly.

Western Aden Protectorate (WAP): There is a well defined coastal plain about 30 miles (48 km) wide which runs into a belt of barren hills reaching 7000 feet (2100 m) in height; in the northern regions these hills gradually run into desert. The hills are scarred with wadi (valley) systems, generally dry, and these run to the coastal plain or, in the north, to the desert.

Eastern Aden Protectorate (EAP): This also has three regions but the coastal plain is narrower, the hills less jagged and more plateau topped, and less broken up by wadi systems; the desert area is very much bigger.

There is one very large and important wadi in the EAP, the Wadi Hadhramaut. This runs 365 miles (588 km) SE from the desert where it is 40 miles (63 km) wide to the sea where it is perhaps five miles (eight km) wide. Another important wadi joins it near its north-west end, the Wadi Duan.

Aden Colony is an area of 75 square miles (194 km^2) on a peninsula 100 miles (160 km) east of the western corner of the WAP. It consists of an isthmus of sandy desert leading to a large mountain; houses are built on the isthmus and round this mountain.

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[1] The political divisions and systems of government described here were those at the end of 1962, when the authors' visit took place.

Climate (see Appendix 1). Reliable information has been collected by the Royal Air Force at Aden and Riyan (the airport of Mukalla) and this illustrates the climate of the coastal plain. Information is also available from Dhala (4500 feet (1370 m)) and Mukeiras (7000 feet (2100 m)); these figures illustrate the climate of the middle mountainous region. The figures for Beihan are less reliable but give some indications of the conditions on the fringe of the desert and the mountains.

Population. The people live mainly in tribal groups; all population figures are estimates and very inexact. (See Appendix 2.)

Movement of Population. In the Western Aden Protectorate there is a considerable population movement; tens of thousands move annually between the Yemen and the Aden Colony; thousands between the Yemen and the cotton areas (Abyan and Lahej), the Yemenis supplying the casual labour to both places. There is also much internal movement of the peoples. In the Eastern Aden Protectorate large numbers of the people go abroad to find work mainly in Saudi Arabia, Kuwait, Indonesia and East Africa.

Nomads (Bedouin, commonly known as "Bedu") are found in the northern desert areas of both Protectorates. However, most of them are not truly nomadic, and usually live in some sort of settlement for some months of the year. This is especially true of the WAP where there is a large salt trade with the Yemen. In the EAP the Bedu are more truly nomadic, following their flocks into the deserts of Saudi Arabia and the Yemen; very few, however, have no fixed abode at all.

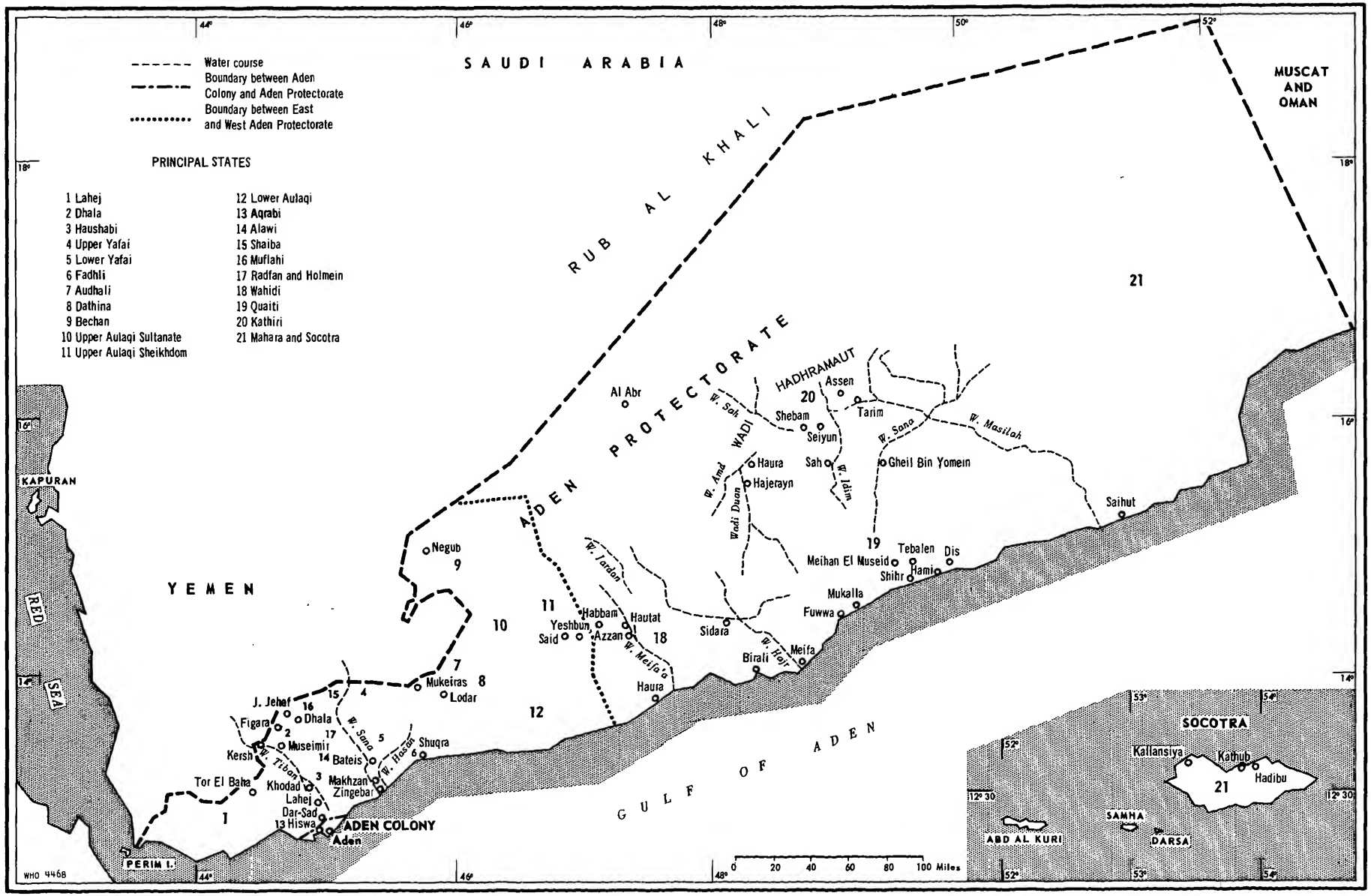
System of Government. The Protectorates can be considered in two main parts, the administered areas and the non-administered areas.

(a) Administered areas

These fall into four main groups: (i) the Federal Government; (ii) the Quaiti State; (iii) the Kathiri State; (iv) other states which are guided in their administration by Her Majesty's Government (HMG).

(i) The Federation of Arab Amirates of the South is a collection of independent states which in 1959 formed a Federation. This is in treaty relations with HMG who give advice and financial help. The Governor of Aden, through the British Agent, gives advice (formal or informal) to the Supreme Council of the Federation which is the ruling body of the Federation and consists of a council of ministers including a minister of health drawn from the various states; there is no prime minister, each

FIG. 1


Water course
Boundary between Aden Colony and Aden Protectorate
Boundary between East and West Aden Protectorate
PRINCIPAL STATES
1 Lahej
2 Dhala
3 Haushabi
4 Upper Yafai
5 Lower Yafai
6 Fadhli
7 Audhali
8 Dathina
9 Bechan
10 Upper Aulaqi Sultanate
11 Upper Aulaqi Sheikhdom
12 Lower Aulaqi
13 Aqrabi
14 Alawi
15 Shaiba
16 Muflahi
17 Radfan and Holmein
18 Wahidi
19 Quaiti
20 Kathiri
21 Mahara and Socotra
SAUDI ARABIA
MUSCAT AND OMAN
RUB AL KHALI
ADEN PROTECTORATE
HADHRAMAUT
YEMEN
ADEN COLONY
GULF OF ADEN
RED SEA
KAPURAN
PERIM I.
Aden
Lahej
Dar-Sad
Hiswa
Khodad
Tor El Baha
Kersh
Figara
J. Jehaf
Dhala
Museimir
Bateis
Makhzan
Zingebar
Shuqra
Mukeiras
Lodar
Negub
Habbam
Yeshbun
Said
Azzan
Hautat
Haura
Sidara
Birali
Meifa
Mukalla
Fuwwa
Meihan El Museid
Shihr
Hami
Tebalen
Dis
Saihut
Gheil Bin Yomein
Sah
Haura
Hajerayn
Shebam
Seiyun
Tarim
Assen
Al Abr
W. Sah
W. Amd
Wadi Duan
W. Idim
W. Sana
W. Masilah
W. Jardan
W. Meifa'a
W. Hasan
W. Tiban
W. Sana
SOCOTRA
Kallansiya
Kathub
Hadibu
ABD AL KURI
SAMHA
DARSA
0 20 40 60 80 100 Miles
WHO 4468

taking turns to be the chairman of the council. The Ministry of Health is responsible for all health matters in the Federation. The Minister has his own staff under the Director of the Health Service and may call on the advice of the Health Adviser, Aden Protectorates; in practice there is a very close working relationship between the two departments.

Each member state has its own government headed by a sultan or amir who is elected for life from a royal family by the important tribal leaders. The standard of administration in each state varies considerably, being advanced in some parts such as Lahej and non-existent in other parts such as the north of the Lower Yafai.

As regards health, the Federal Government has assumed complete responsibility throughout all the member states except in two cases, Lahej and Dathina, where a Director of Health undertakes some public health duties; the extent of the responsibilities of these Directors of Health has not been finally laid down.

The relation of the Federation and the Colony is about to become much closer with the merger of the two.

(ii) The Quaiti State, and (iii) the Kathiri State are both in treaty relations with HMG; the treaty differs from the Federal one in that it only guarantees defence; there is a council of ministers, one of whom is the first minister, each minister being responsible for the running of his department. In both the above states the administration is of a relatively high order.

(iv) Other states guided by HMG. In this group an HMG officer is attached to a state and by persuasion tries to influence the tribal leader; there is usually no administration in the modern sense.

(b) Unadministered states

These are states where there is only tribal organization and where there are no advisory staff. They include part of the Lower Yafai, the Upper Yafai and the Mahara Sultanate.

Education. In the Federation secondary and intermediate education is a Federal responsibility, primary a state responsibility. At present the only secondary education available is in Aden Colony, but secondary schools are being built in Mukalla and in the Federation.

Housing. There is no town and country planning. Villages grow up round the chief's house. There is usually a well and a mosque in each village. Mud is the standard building material except in the hills, where stone is much used.

Lower class housing. The desert Bedu either sleep in the open or have very small, cramped, goats' hair, black tents. The settled peoples usually build single-roomed brushwood or reed houses. The walls may be plastered with mud. More prosperous members may build mud, or dry stone, single-roomed dwelling places.

Lower middle class housing (the poorer chiefs, small shopkeepers, etc.). This is a mud-brick or stone house of two or three stories. Even if mud is used, the foundations are of stone. The walls are thick and sloped slightly towards the roof; the house is constructed round a central staircase with a central pillar. The rooms are small as the elb tree, the only local source of wood used to support the roof, is short. The beams of the roof are overlaced with elb branches and the floor above made of mud placed on these branches. The ground floor usually has no windows and is used to house the goats and other livestock. The first floor has small wooden shutters but no glass in the windows, and forms the main sitting room. The room above is similar and will be the women's quarters with the kitchen near it. The roof is used for sleeping out. Tribal houses are built for defence, whereas merchants' houses are not and have bigger windows, and the ground floor is often used as a shop. The upper middle and upper classes in the hills have bigger versions of the above type of house; there are substantial stone houses in the towns, with large windows and rooms (imported timber being used for the roofing). The walls are plastered and whitewashed.

Communications. Aden Airways provide a regular service to most of the larger towns - e.g., Mukeiras daily, Beihan twice weekly, Mukalla thrice weekly. The Royal Air Force also fly planes to many other smaller airstrips.

The only important sea route is the Aden-Mukalla route. This, however, only occurs regularly in the months of the south-west monsoon, i.e., from October to April. During the rest of the year sea transport is most irregular due to the rough seas.

Roads are by far the most important method of communication, though most are little more than improved tracks. Fifteen miles per hour is the average speed on most roads.

Finance. The economy of the Protectorate depends mainly on remittances from citizens abroad, cotton and vegetables in the WAP, and the fishing industry and subsidies from Her Majesty's Government.

Organization of the Health Services

The organization of the health services of the Aden Protectorate is in a state of flux; a federal service has recently been set up in the Western Aden Protectorate; it is expected that this service will soon amalgamate with the health service of the Aden Colony. This reorganization will probably affect mainly the higher organization of the service rather than the units in the field who carry out antimalarial work.

At the moment, there are three health services, the federal health service, covering the Western Aden Protectorate (and Wahidi), the Quaiti health service and the Kathiri health service. The last two cover the two administered states in the Eastern Protectorate.

The health adviser to the Protectorate, who gives advice to the three health services, provides a link between the services. He is also responsible for some staff either attached or seconded to the three services. Various specialists responsible to the health adviser have been attached to the health services, especially to the Quaiti state service, and it is expected that a senior public health inspector will soon be available for attachment to the Federal Service. The health adviser is also responsible for certain rudimentary health services in some of the unadministered areas.

Medical and health work in the field is carried out by senior medical officers and medical officers in the districts; each has both clinical and preventive responsibilities. They also act as advisers to the various municipal health boards (at Lahej, Zingebar and Mukalla). The medical officers are centred on hospitals at Lahej, Makhzan, Lodar, Mukalla, Seiyun, Shibam, Duan and Shihr. Hospitals at Said and Azzan are under construction. They are also responsible for the work of the health units in their districts. These units are in the charge of health assistants

and are scattered widely throughout the Protectorates, covering usually populations of less than 10 000 (see Appendix 2). These health assistants have both curative and preventive responsibilities, the former occupying by far the greater part of their time.

There are also two mobile sanitary units which consist of about five or six labourers supervised by a health assistant. These units are under the control of the district medical officer and have been used mainly for carrying out spraying with residual insecticide. They are based on Nakhzan and Mukalla, but may be sent to other places as required. The formation of new mobile sanitary units is planned.

The backbone of the health services are the health assistants who staff the hospitals, health units and the mobile sanitary units. There is some difference between their terms of service in the Eastern and Western Protectorate services. Qualifications for entry and standard of training are gradually rising. This means that the abilities of those at present in the service vary widely. In the Federation applicants for training should have completed intermediate schooling, but exceptions are made. They then undergo a three year training course with examinations at the end of each year. The principal training is given at Makhzan and Mukalla hospitals. About 30 are at present training.

At the end of 1962 there were 180 health assistants at work and in training. A few students from the Protectorate are studying for medical degrees outside the country. There are as yet no candidates for training in the intermediate medical grades which require their trainees to have successfully completed secondary education.

In addition to the services described above there are the health branches of the various security services, but their composition has little relevance to the problem of country-wide malaria control.

Antimalarial Operations Carried Out by the Health Services

The diagnosis and treatment of malaria cases is carried out in hospitals and health units. In 1961, 16 808 cases of malaria were diagnosed and treated. The distribution of the cases reported by health units is shown in Appendix 3. Except in hospitals, diagnosis is clinical. Treatment has been standardized as one day treatment with amodiaquine. Chloroquine is available for parenteral use in emergency; several clinicians have mentioned that great care has to be exercized in using parenteral chloroquine treatment in young children. 8-aminoquinolines are not used.

In addition to curative work, health assistants may apply for residual insecticide to carry out spraying operations in their own district. This is usually done when the number of cases of malaria, or the mosquito nuissance, is causing concern. Each health assistant is provided with a "Warley" Eclipse pressure sprayer.

A great deal of antimalarial work has been carried out in Abyan by the mobile sanitary unit in connexion with the development and irrigation of this area by the Abyan Cotton Board. As Abyan is the site of the main antimalaria effort in the Protectorate it deserves a rather fuller description. (Appendix 4.)

The records kept of antimalarial operations consist of a record of the number of drums of insecticide issued by the Federal Medical Stores to the mobile sanitary unit in Abyan, and a record kept by the health assistant in charge of the mobile sanitary unit of the numbers of rooms sprayed and of the days on which the squad worked on house spraying.

From August 1960 until October 1962, 108 (x 45 lbs (20 kg)) drums of 50% w.d.p. BHC were issued for use in the Federation; 61 to Makhzan (Abyan), eight to Lahej, and the rest for the use of individual health assistants.

During 1961 the mobile sanitary unit in Abyan received 34 drums with which they sprayed 21 029 rooms in Abyan and 21 078 rooms in other towns, 115 days being spent in spraying operations, 74 days in Abyan and 41 days outside. It seems that the timing of spraying was based on the receipt of insecticide which in its turn depended on the availability of funds during the financial year. (The implication of these figures and further inquiries made during the present visit are discussed later.)

No direct assessment is made of the effect of these operations. Indirect evidence from hospital and health units' returns (Appendix 3) is very difficult to interpret. Gillies in 1957 reported that he had been told that about a third of out-patients in Abyan were suffering from malaria. The annual report for 1957 gives much lower figures. In Makhzan hospital there is a report of 126 positive blood films in the last six months of 1957, four in the whole of 1958, and 254 in 1961, but these variations may merely reflect staff changes.

The municipality of Zingebar in Abyan also carries out residual spraying operations purchasing its own insecticide and employing its own spraymen; these are not under the control of the health assistant in charge of the mobile sanitary unit. There is no record available of the number of houses sprayed. It is understood that spraying is aimed at the reduction of the mosquito and fly nuisance.

In the Eastern Aden Protectorate there is one mobile sanitary unit in Mukalla, responsible for spraying operations in the whole protectorate. Another one is to be formed and will work in Seiyun.

The principles on which the squad works are the same as those in the Federation, but the actual personnel are much more experienced and efficient. The senior medical officer, who takes a considerable interest in antimalarial work, fully understands how residual spraying should be used to prevent malaria. The health assistant in charge of the squad understands the techniques of spraying, and has an experienced squad of spraymen who have remained unchanged for several years. Good records are kept of the spraying operations carried out, including measurements of the surface sprayed and the amount of insecticide used (though they have not been carried to the logical conclusion of working out what dose of insecticide has actually been applied). Spare parts are available for the pumps. Legal methods are available for dealing with refusals to permit house spraying, and these have, on several occasions, been used. Care is taken to plan the operations so that the local authorities and the public are informed in advance.

It is disappointing that in spite of an efficient spraying team and intelligent direction, it has not been possible to plan operations so that malaria can be prevented; there are two reasons. First, there is never enough insecticide; the Quaiti State budget makes it possible to buy only 20 x 45 lbs (20 kg) drums a year of 50% γ-isomer BHC water dispersible powder. Secondly, requests from local authorities often make it necessary to use much of this insecticide for reasons unconnected with malaria control. This results in the insecticide being used in the most uneconomical way. Spraying does not start until cases of malaria are causing concern, which may be long after the main period of transmission.

Records submitted by the mobile sanitary units and individual health assistants of houses sprayed during 1956-1961 indicate the following antimalarial achievement.

	Houses sprayed	
	WAP	EAP
1956	7 995	2 957
1957	31 260	1 332
1958	36 920	4 135
1959	19 333	2 727
1960	37 448	12 033
1961	21 357	No return available

Training of staff engaged in antimalarial work. The health assistant in charge of the Federation mobile sanitation unit has not received any formal training in antimalarial work. He has received instruction from various medical officers who have taken an interest in antimalarial work. He is responsible for the training of his spraymen and also for giving instruction on antimalarial work to trainee health assistants during their three year course of instruction at Makhzan, and during the refresher course for health assistants held annually. There does not appear to be any written syllabus for training in residual spraying. Dosage, area covered and timing of operations are all left to the discretion of the health assistant in charge of the mobile sanitary unit or the local health assistant.

Finance and supplies. The funds spent on antimalarial work in the Federation (WAP) are the salaries of those part-time on antimalarial work and the cost of insecticide. No one is employed full time; the mobile sanitary units have other duties.

The amount of insecticide imported has been constant during the past few years at 60 (x 45 lbs (20 kg)) drums of 50% w.d.p. BHC costing about £ 17 (US$ 48) a drum. On occasions extra supplies have been bought locally at a slightly higher cost.

The following expenditure on antimalarial work in 1961 can be identified.

60 drums of BHC (50% w.d.p.)	£ 1 025	US$ 2 870
5 drums bought locally	110	308
Part of wages of mobile sanitary unit:		
Health assistant (for 115 days)	150	420
5 labourers (for 115 days)	230	644
Labour employed by other health assistants for antimalarial work	92	258
	£ 1 607	US$ 4 500

It is difficult to assess the value of the part-time work of the other personnel, transport and equipment, but it appears that about a total of £ 2000 (US$ 5600) a year is spent on antimalarial work in the Federation. A few drums of insecticide are also purchased for municipal use, mainly to prevent the breeding of nuisance mosquitos.

Information About Incidence of Malaria

Most of the information available about the incidence of malaria in the Aden Protectorate is to be found in the annual reports of the Medical Department. There are also available two reports of special surveys, that of Petrie and Seal carried out in 1939-1940, and that of Gillies carried out in 1957. The latter was purely entomological. During 1961 an Assistant Health Adviser, Dr G. W. G. Hunter, carried out a general medical survey of many parts of the Protectorate and included estimations of spleen rates in his observations (Appendix 5). He also made knockdown catches of anophelines in several areas.

From these reports it seems possible to define three areas of malaria endemicity.

(i) Those areas with water suitable for anopheline breeding for considerable periods of the year where malaria is endemic, usually at a fairly low level. These are: the Abyan district; the cotton growing area around Lahej; part of the Wadi Yeshbum and the nearby towns of Habban and Hautat in Wahidi; Wadi Hajr in the Quaiti State; several less well defined areas in the Federation near Tor el Baha, Kersh, Museimir and Figara.

(ii) Those areas where transmission is not likely. These are areas over 5000 feet (1525 m), namely Jebal Jehaf itself and the Mukeiras plateau and also the extremely dry areas bordering on the great Arabian desert.

(iii) The rest of the Protectorate where transmission may take place at certain times of the year. In some of these places (e.g., Dhala and Lodar) epidemics of malaria have occurred from time to time.

The figures of malaria cases from the health units in general confirm the picture given above (Appendix 3).

Parasitological confirmation is only available from a small proportion of cases admitted to hospitals so that the laboratory reports, while confirming that malaria does occur, give little information about the incidence.

It is considered that immigrants from the Yemen are heavily infected with malaria. Treatment of these infected Yemenis may swell the figures for malaria infection from health units along the routes of immigration.

Entomological reports suggest that Anopheles gambiae is by far the most important vector. It is probable that A. sergenti is important in some of the inland areas. The position of A. dthali is uncertain. These conclusions are based on the work of Gillies, who visited the Protectorate for a month in 1957.

Malaria is considered to be heavily endemic in the island of Socotra, but, except for the rather unreliable figures from the health assistant included in Appendix 3 and a short note in the preliminary report of the Oxford University Expedition to Socotra in 1956, there seems little definite evidence at present available to support this opinion.

Malaria in Neighbouring Countries[1]

Saudi Arabia

Control operations against malaria, with assistance from WHO, have been carried out successfully for six or seven years using residual insecticide. Preparations for the eradication of malaria from the whole country are now being made. It is considered that the area of the border between Saudi Arabia and the Aden Protectorate is non-malarious.

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[1] From information supplied by the Malaria Unit of the Eastern Mediterranean Regional Office of WHO.

Some of the information about malaria collected in Western Saudi Arabia is probably relevant to Aden conditions. A. gambiae is the chief vector and A. sergenti is of secondary importance. The conditions in Eastern Saudi Arabia where A. stephensi is a vector (and resistant to DDT) are probably not relevant.

A. gambiae has been found breeding in wells, flowing streams, surface water and man-made containers either of mud or cement. Its resting places in the houses have often been found to be articles hanging on the walls rather than the walls themselves. Precipitin tests of stomach contents showed human blood in 71% of the species collected from human habitations. The sporozoite rate has been found to be about 0.3%; A. gambiae is susceptible to DDT.

A. sergenti has been found breeding in irrigated fields, irrigation canals, wells and surface water arising from springs. It has been found resting inside houses and animal shelters and in caves and observed newly fed in uninhabited houses. There are probably other outside resting places, as yet undetected. Fifteen per cent. of specimens collected from a variety of resting places contained human blood. The sporozoite rate is also about 0.3%, and A. sergenti is susceptible to DDT. The malariologists in Saudi Arabia have come to the conclusion that A. sergenti is easy to control with residual insecticides in oases but difficult to control where it can rest outside houses in rock holes and in caves.

Yemen

A survey was carried out in January 1962, in villages in the Yemen on the Saudi Arabia border by a WHO malariologist (Dr Gamal Sami Ahmaed) attached to the Saudi Arabia malaria project. In the Khabt valley, with a population of 4000 on the edge of the desert and at an elevation of 3800 feet (1160 m), he found a spleen rate of 30.2% and a parasite rate of 8.1%. In the Al Gawf valley, with a population of 12 000, and at an elevation of 3200 feet (975 m), he found a spleen rate of 8.0% and a parasite rate of 6.4%. There was difficulty in obtaining blood samples from the villagers as general medical treatment was always demanded before a film could be made.

A resumé of the malaria situation in the Yemen supplied by Dr C. R. Jones (personal communication) states that malaria is one of the most important diseases of the Yemen. It occurs all over the country and up to elevations of 8000 feet (2440 m),

and even higher. It is hyperendemic in the mountain valleys of the foothill regions and in some of the Tihama oases. Serious foci are reported at Zabid, Baital Faqih and Hais in the lowlands, and from around Taiz and Madinat-Abid in the middle heights. In 1957 a spleen index of 68% was found in 66 schoolchildren in Taiz, 17% in Hodeida and 2% in Sana. Malaria occurs all the year round in the coastal region. In Taiz its greatest peak is in November and December. The local doctors consider that Plasmodium falciparum predominates in the Tihama and foothills, and P. vivax on the plateaux, whereas P. malariae accounts only for a small percentage of the cases. It is generally believed that A. gambiae is the principal vector in most of the gravely affected areas. A. sergenti is suspected as a vector in Sana, and A. culicifacies adenensis along the coast in Hodeida. A. gambiae is found breeding in the sunlit collections of water in the area in and around Taiz, and at locations on the roads between Taiz and Sana, and Taiz and Hodeida. Larvae have been found in irrigation seepages, small streams in wadi beds and in roadside drinking places. They have also been found in the ablution places of the mosques in Taiz. Other species identified by various observers, including Buxton (1944) are A. turkhudi, A. cinereus, A. dthali, A. pharoensis and A. pretoriensis, but none of these is considered important.

Muscat and Oman

No information available.

Jordan

Although Jordan is far from the Aden Protectorate, the problems of dealing with A. sergenti may be comparable in both countries. It has been found that transmission carried by A. sergenti in parts of Jordan cannot be controlled by residual spraying and that larviciding is required. The methods adopted are:

Repetitive larviciding in accessible places using malariol with DDT in summer and without DDT in winter; applications are made weekly. It has been found that in summer the intense heat breaks up the oil film and renders it ineffective unless an insecticide is used in addition.

In the more inaccessible places residual larviciding is employed. Insecticide is sprayed on the banks in the same dose as is used for walls. It is applied once a month.

It is reported that these measures are effective, but much more expensive than residual spraying.

RESULTS OF THE INVESTIGATION

Objectives and Methods Employed

The objective of the investigation was to collect information that would enable useful advice to be given on the incidence of malaria; the nature of the vector; and the most suitable antimalarial operations that could be undertaken.

There were two alternative approaches to this investigation; either to cover a wide area or to concentrate on one area and collect as much information about it as possible.

In the time available it was neither possible to visit all parts of the Protectorate nor to collect detailed information about one area, particularly as conditions vary so much from one period of the year to another and a compromise was adopted.

Methods of investigation. The following methods of investigation were used: assessment of spleen and parasite rates; search for anopheline larvae; knockdown and hand catching of anophelines in houses and stables; and night catches of anophelines.

In addition discussions were held with those responsible for antimalarial operations in each area visited and, where possible, spraying operations in progress were observed.

Special investigation. The following problems of special interest were also investigated: (i) the survival of vector species during the dry season; (ii) the susceptibility to insecticide of A. gambiae in the Abyan area; (iii) the collection of eggs of A. gambiae to enable further investigations on a strain of this species from Abyan to be carried out in the Ross Institute, London.

Results of Investigations in the Federation

On the whole the observations carried out in the Federation confirmed the impression of the malaria situation that had been gained from information already available. There were noted, however, several points of particular interest.

The area of high endemicity of malaria in the cotton growing areas, both in Abyan (Map 2) and Lahej (Map 3) is limited to the upper part of the irrigated areas. In the lower parts of Lahej, breeding places and therefore adult anophelines, were hard to find even in November (i.e. relatively early in the dry season). In Lahej breeding does continue even in these less malarious areas, a few newly hatched A. gambiae were found in houses and pupae of A. gambiae were found in a concrete tank in a mosque. In Abyan the incidence of malaria was much lower in the area near the sea. (Appendix 5 and Map 10.)

In the areas visited, where only seasonal malaria is to be expected (Dhala (Map 4) and Lodar (Map 5) districts) the incidence of malaria was much lower than in Abyan, but in several places there was permanent water and, near Lodar, larvae of A. gambiae were found. A nearby village constituted a small focus of continuous transmission of malaria. In other places, such as Amwadhia, little malaria was found, but this low incidence has been associated with several years of little rain.

The usual pattern of rainfall in these areas is a few inches in April and May, a fairly dry June and several inches in each of July and August. A year of good rains following the recent dry years might well be expected to produce an epidemic of malaria. (The last epidemic in Dhala was about 10 years ago, according to the local health assistant. Lodar experienced an epidemic in 1953.)

In Jebel Jehaf and Mukeiras (Map 6) (altitude of both about 7500 feet (2285 m)), no evidence of transmission was found, though it may possibly occur in the hotter and wetter months. But it is considered that these areas represent the parts of the Protectorate with the smallest risk of malaria. Anophelines were found in both areas, but they were not recognized vectors. Cases of malaria have been reported from Mukeiras by the military in the past, but it seems that none of them was supported by a positive blood film. Experienced health assistants in both areas, who had previously worked in places where malaria was endemic, were of the opinion that local transmission did not occur.

Results of Investigations in the Eastern Aden Protectorate

Our observations indicate that malaria in the East Aden Protectorate falls into two clearly defined groups. Malaria in the coastal area and malaria in the Wadi Hadhramaut.

In the coastal area malaria endemicity resembles that in the Western Aden Protectorate. The vector is Anopheles gambiae. There are a few areas where transmission continues all the year round; there are several where the transmission occurs seasonally after rains that fall in a definite season (in this case from November to March). There are other areas where malaria transmission practically never occurs.

Only one area was visited with a high endemicity and continuous transmission, the site of a new irrigation scheme at Meifa Hajr (Map 7). There are other areas further up the Wadi Hajr where conditions are reported to be similar. At Meifa Hajr a high spleen and parasite rate was found and adult A. gambiae were caught gorged with blood.

The situation here is similar to that in Abyan. It must not be forgotten that the immigrants expected in this area when the new irrigation scheme comes into effect will be very susceptible to malaria.

The villages with seasonal transmission are found lying a few miles inland from the coast, and stretch from the villages behind Mukalla to Dis (Map 8). Several of these villages, Aees, Meihan el Huseid and Tebaleh were visited but there was no evidence of transmission at the time of the visit and no A. gambiae were found breeding. In Fuwwa, though there was a moderate spleen rate (13%) no A. gambiae were found. It seems that transmission lasts for several months at Fuwwa but is not continuous. In the coastal village of Hami, A. gambiae appeared to be absent, but A. azaraе and A. dthali were seen in large numbers. It is reported that malaria transmission is unknown in Hami although severe outbreaks have occurred at Dis which is only a few miles away. The reasons for this difference are obscure.

As the malaria situation in the Wadi Hadhramaut is so different from that found in the rest of the Protectorate, it is described in more detail, and includes observations on the antimalarial measures carried out.

The Wadi Hadhramaut and its branches consist of a cleft in the high plateau of the Eastern Aden Protectorate (Map 9). It contains many large towns. The populated part of the wadi extends approximately 70 miles (110 km) from East to West. The Wadi Duan which enters it from the south is about 45 miles (70 km) in length.

Both the main wadi and Wadi Duan have a population of about 120 000 each. There is no running water in the wadi itself. Most of the cultivation depends on water drawn from wells. In the branches of the wadi and in a few places in the wadi itself, there are pools of water present all the year round. At irregular intervals rain falls on the surrounding plateau and less frequently in the wadi itself. The rainfall results in floods, which produce very large numbers of pools both in the wadi beds and surrounding low ground. The length of life of the pools depends on the size of the flood, but often exceeds three weeks.

The frequency of these floods in different parts of the wadi varies, depending on their situation. It is very unusual for the whole Wadi Hadhramaut and its branches to flood at the same time; this will probably occur only once in 10 years. Shibam, situated where several small side wadis join the main wadi, has a flood about once a year. Tarim and Seiyun about once every three years. There is flooding in the Wadi Duan about once every other year. The timing of these floods is quite irregular, but occurs more frequently in the hot weather, that is from March to September.

Usually anophelines are absent from the large towns in the main parts of the wadi system. We searched in what we considered the most likely places and found anophelines breeding in about half a dozen sites of permanent water at the periphery of the wadi. There must, of course, be many other such bodies of permanent water which we did not have time to locate. Two vector species were found, A. sergenti and A. fluviatilis. Moderate numbers of larvae of both of these species were found in a few wadi pools and one A. sergenti larva was found in a disused well at Sah. Some anopheline larvae were also taken from a well at Khemoor, near Shibam, but they were too small to identify. Adults of both species, too, were collected from a few human dwellings and animal quarters near the larval sources. One A. sergenti was taken biting human bait, outside, one hour after sunset. It is reported that, after a flood, very large numbers of anophelines are found in human dwellings in the affected areas.

Previous reports of A. sergenti from the wadi by Hoeck and Merucci (in Mattingly & Knight (1956)) indicate that this species was found in Shibam and Tarim. The health assistant in charge of mobile sanitary units, reports that residual spraying with BHC during outbreaks of malaria in towns in the Hadhramaut results in many dead anophelines being found in the house immediately after spraying and on several subsequent mornings.

Usually there is very little transmission of malaria in the wadi itself, though there are reports of infrequent cases of malaria all through the year at a few towns and villages near permanent water, where A. sergenti and A. fluviatilis were found, such as Khon and Al Urd. The Senior Medical Officer of Kathiri State, reports a similar focus near Tarim. Although both A. sergenti and A. fluviatilis were found, the former is the most likely vector; identification of the anophelines present at the time of malaria transmission is urgently required. Spleen and parasite surveys at Qassem revealed no evidence of recent transmission. The positive results at Sah were probably due to transmission during a recent flood.

Severe outbreaks of malaria occurring after floods are well recognized. Several small floods at intervals of a few weeks are reported to produce more malaria than one large one. In 1962 a flood in August at Shibam was followed by about 700-800 cases of malaria; another small flood in October was followed by about 100 cases. The Medical Officer at Shibam, who took a series of blood films, showed that the causative parasite was P. falciparum. He was not, of course, under the conditions of the outbreak, able to take blood films from all cases of malaria. There were also outbreaks of malaria in Tarim and Sah in 1962.

The antimalarial measures available are larviciding and house spraying with residual insecticide. These measures are undertaken by the health inspector at Shibam, and by health assistants in other areas. The mobile sanitary squad in Mukalla is available if required, but has not worked in the wadi for several years. It is planned to set up a mobile sanitary unit in Seiyun for use throughout the wadi.

The efficiency of the present antimalarial measures is impaired by the shortage of insecticide. Neither in Shibam or Tarim in 1962 was it possible to complete the spraying programme during the outbreaks as supplies of insecticide were exhausted and local funds were not available to purchase any more. This shortage of insecticide has resulted in an instruction by the local councils that spraying is not to be started unless there are actual cases of malaria. Health assistants newly posted to units in the wadi have only a theoretical knowledge of how to carry out residual spraying. Discussion and observation in such units during our visit did not make one confident that they would be able to carry out spraying efficiently in an emergency. With the one pump available to them, they would only be able to cover a fraction of their district in the time available.

Detailed Entomological and Parasitological Results

During our visit, entomological and parasitological surveys were made in as many areas as possible. Our headquarters was in Abyan, and observations were made there throughout the period (26 October to 21 December 1962). The results are summarized in Appendix 6. Susceptibility tests were carried out both in Abyan and in London (by Mr G. Davidson of the Ross Institute) on mosquitos reared from eggs sent by post from Aden. The results are given in Appendix 7. Although there were some survivors when A. gambiae was exposed to DDT for one hour, attempts to select a resistant strain were not successful, and it is probable that this rather large-sized strain of A. gambiae shows some tolerance to DDT but no resistance.

Abyan (Maps 2 and 10)

Anopheles gambiae was found as larvae and pupae in borrow pits and swampy pools near El Kod, in pools in the Wadi Bana, Nabwa swamp, Wadi Nazat El Rimila near Gaar, and in shallow pools produced by earth moving equipment in the construction of an irrigation system near Makhzan. Adults of A. gambiae were found in buildings in the compound of Makhzan Hospital, in houses in the villages of Makhzan, Seyhan and Bateis, and in outside night catches on human bait at the latter. Other anophelines found in Abyan were A. sergenti (only at Bateis) and A. dthali.

Tests were carried out on wild caught and on laboratory reared adults of A. gambiae but the results showed no evidence of increased resistance to BHC. These results were subsequently confirmed by experiments in the London School of Hygiene and Tropical Medicine on a colony of A. gambiae reared from eggs of Abyan mosquitos. (See Appendix 7.)

Examinations for spleen rates were made at El Kod (10%), Musemer (9%), Zingebar (6%), Makhzan (23%), Oberothman (70%), Gaar (10%), Der Gag (24%), Rawa (37%), Husn (26%) and Bateis (64%). (See Appendix 6.)

At the same time blood slides were taken and parasite rates established for two of the above villages: Makhzan (9%) and Bateis (27%). In addition, blood slides were taken from 19 children from seven months to seven years of age at a women's and children's clinic at Bateis. These gave a parasite rate of 52%. The parasite in all cases was Plasmodium falciparum.

Abyan is an important and populous cotton growing and general agricultural area and as the headquarters for our visit of two months was situated in the district (Makhzan Hospital), it seemed appropriate and convenient to devote rather more time to it than to other areas.

In October, myriads of larvae of A. gambiae were found in shallow pools produced by the operations of bulldozers in making a dam for irrigation purposes. This breeding ground was less than a mile (1.6 km) from Makhzan Hospital compound, and was used by us as a source for rearing adults for susceptibility tests. It is true that, after four weeks, this source had dried up but more larvae were quickly found in residual pools in the nearby Wadi Bana. An hour's search in the morning in houses in Makhzan village would be likely to yield some 30 A. gambiae, perhaps two or three A. dthali and a few culicines at any time during the period of our stay in the country. Similar catches were obtained from the next village, a few miles to the north-west, Seyhan.

At the end of October, knockdown spray catches were done at Bateis and, in one mud and straw hut, more than 200 mosquitos were taken. With the exception of four A. dthali, they were all A. gambiae. A nearby area of swampy ground, known as the Nabwa Spring, yielded many A. gambiae larvae. Bateis is in the north of the Abyan agricultural area and is virtually the last group of "gardens" adjacent to the headwaters of the Wadi Bana, and irrigated by it through a series of sluices. A. dthali larvae were found in the stony pools along the banks of the wadi, but it was felt that only the lack of time to search prevented A. gambiae from being discovered as well.

With the help of some of the local health assistants and our drivers as bait, a night catch was done in the Bateis gardens, near mud houses and one of the bigger irrigation channels (in which anopheline larvae too small to identify were later found). Many sand-flies were biting but 18 A. gambiae were taken in about an hour. A nearby cow tethered out of doors was examined and five culicines and one anopheline, A. sergenti, were taken feeding on her.

In the middle of December, Bateis was again revisited and knockdown spray catches were done in a rush house and an adjoining compound with rough cover for goats. The human habitation produced six male and 47 female A. gambiae and seven female A. sergenti. The goat "shed", 15 male and 33 female A. gambiae and one female

A. dthali. Another night catch was attempted, with humans and cows as bait, in the same place as six weeks earlier, but only two culicines were taken on the cow. It had become much cooler, which might have deterred A. gambiae from biting outside. However, one of us captured three A. gambiae and one A. dthali by torchlight in a large building providing shelter for several people and cows.

Two more breeding places of A. gambiae were confirmed at this time. One was the Wadi Nazat El Rimila, and was a roadside channel near Gaar on the Bateis road (A. dthali was also found here); the other was in the south of the Abyan area in the form of borrow pits and swampy pools near El Kod.

The finding of A. sergenti is interesting. Gillies (1957), points out that this species has not been recorded from the coastal belt in Aden, and indeed, it might well be argued that Bateis, 20 miles (30 km) or so from the coast and almost in the foothills of a series of formidable mountain ranges, is really an inland region. Elsewhere in the West or East Protectorate, A. sergenti might have been viewed with more concern, but here in the presence of so many A. gambiae, with so many seemingly persistent water sources, it is difficult to regard it in the role of a vector of any great importance.

Prior to our visit in October 1962, the Assistant Health Adviser to the Protectorate Health Service, did a number of knockdown spray catches in various places in the WAP. He found A. gambiae and A. dthali as did Gillies (1957).

The ten spleen rate figures which cover the entire Abyan area provide useful information for control purposes. The three places near the coast, the villages of El Kod (10%), Musemer (9%), and the town of Zingebar (6%), have the lowest rates with the exception of Gaar town (8%). With that exception, all the rest of the towns and villages to the north have significantly higher spleen rates.

In estimating parasite rates, the two to nine year age-group was normally used and any falling outside this category is quoted separately. Routine slide examination consisted of the scanning of 100 fields of the thick blood film. A rough but quick and reasonably comparative method was evolved for estimating the number of parasites per mm^3 in infected blood slides. Parasites were counted against leucocytes, assuming a WBC of 8000 per mm^3. A figure of 1-100 per mm^3 would be recorded as a scanty infection, 101-1000 a moderate infection and 1001 or more a heavy infection.

Makhzan had a parasite rate of 9% for the two to nine years of age group. Of the four infected slides, three were scanty and one heavy infections. There were no parasites found in the blood of 53 children in the 10 to 15 years of age group, although these same children showed a spleen rate of 22.5% (a similar rate as for the younger group).

Bateis had a parasite rate of 27% for the two to nine age-group, and of the 11 infected bloods, six were scanty, four moderate and one heavy infections. The 10 to 15 age-group, in this case, was almost identical. The parasite rate was 27% and, of the 13 infected bloods, eight were scanty and five moderate infections. The spleen rates for the two groups were 65% and 60% respectively. At Bateis clinic, 10 of the bloods of 19 children, aged seven months to seven years, were positive with two scanty, five moderate and three heavy infections. One, an infant of one year, was a very heavy infection, which was estimated to be approximately 102 000 parasites per mm^3. Spleen examinations were not done on these children.

Lahej (Map 3)

Khodad, a small town about 10 miles (16 km) north of Lahej town, was selected to survey and compare with Norbet Aiyed, two or three miles (3-5 km) to the south-west of Lahej, as it was desirable to confirm the impression of the local medical authorities that the northern part of the area was more malarious than the southern. Our results did, in fact, confirm this opinion. Khodad, in the upper part of the argicultural area, is flanked on one side by the Wadi Zaghrir and on the other by the Wadi Kebir. Both wadis had long stretches of running water with attendant stony pools and still backwaters in which, in the case of the Wadi Zaghrir, many larvae and pupae of A. gambiae were found. The Wadi Kebir was not examined but it was thought to constitute a similar breeding place. Some miles to the north of Khodad, the two wadis converge and eventually join to become the Wadi Tiban. At this point a large dam has been built and here, on the south side of the dam, larvae and pupae of A. gambiae and A. dthali were found. Further north, again, at the limit of the agricultural area near Shakka, several anopheline larvae were found in the stony pools of the Wadi Tiban. These were too small to identify. Moderate numbers of adult A. gambiae were obtained fairly easily. In one knockdown spray catch in Khodad, 20 A. gambiae and two A. dthali were taken and in another, 40 A. gambiae. A live catch in the morning in the same town yielded 19 A. gambiae and eight A. dthali.

On the other hand, Norbet Aiyed and nearby Goal had no obvious breeding places in the vicinity, apart from wells, which were free from larvae. The banks of the Wadi Kebir fringe the irrigated gardens of Goal but the wadi itself was quite dry at this point in spite of it being still early in the dry season (November). The gardens were efficiently watered by a pump in a well. Only after several examinations and knockdown spray catches were four A. gambiae taken in Norbet Aiyed and one A. gambiae in Goal. On dissection, three of these mosquitos proved to be freshly emerged and the other two could have been.

Spleen and parasite rates were done at Khodad and Norbet Aiyed. At Khodad the spleen and parasite rates for the two to nine age-group was 73% and 17% respectively. At Norbet Aiyed, for a seven to ten age-group, the spleen and parasite rates were 4% and 3.4% respectively. (See Appendix 6.) These figures need no comment. The parasite was Plasmodium falciparum in all cases except one child of five years, at Khodad, which had a moderate infection of P. vivax. Of the five infected bloods in the two to nine age-group at Khodad, one was a scanty infection and four were moderate infections (one of these was the P. vivax). At Norbet Aiyed, the three infected bloods, in the seven to ten age-group, were all scanty infections.

To the north-east of Lahej town and quite close to it, lie a number of villages where a rapid search for breeding places was made. No natural deposits of water were found. Many wells were dipped with negative results, but in the concrete tank of a mosque fountain pupae were collected, and produced two A. gambiae males. This is cited as an example of how a mosquito population can maintain itself during a naturally dry period by utilizing small numbers of man-made water containers.

No anophelines other than A. gambiae and A. dthali were found in the whole of the Lahej area. Dr Hunter collected the same two species in October 1962. Gillies (1957) recorded A. dthali and A. rhodesiensis rupicolus.

Dhala (Map 4)

No natural breeding places were found in the immediate vicinity of Dhala town, but beyond a radius of about three miles there were several. Near Zubeid, a small grassy stream running into rocky pools, the Wadi Nakhra, had moderate numbers of A. sergenti larvae. A few miles from Zubeid, at Mahsina, a rocky pool straddled the

road and a pupa of A. pretoriensis was collected. Again, near the same road, at Zanid, pupae of A. dthali and A. pretoriensis were found. Three miles (5 km) from Dhala town were two wadis, one, a fork of the other, Wadi Ghail El Khumeira and Wadi Thebebe. Although dry for the most part, both had fast running stretches of water for several hundred yards through rocky gorges and over falls. In the great variety of rocky pools and occasional shallow sections with grassy vegetation, larvae of A. dthali, A. cinereus and A. rhodesiensis rupicolus, were collected. Several wells over a wide radius were examined with negative results.

Knockdown spray catches were carried out in many of the fine stone houses of the villages built on hills at Zubeid and the Azariq group of villages, but no anophelines were found. At Khumeira, the result was the same, but at Kurna on Jebel Jehaf (7000 feet (2130 m) a knockdown in a cattle shed produced seven A. cinereus and three A. demeilloni. A night catch was tried with several people and a cow as bait at Khumeira, but no mosquitos were taken.

Spleen and parasite rates at Zubeid School for the seven to twelve age-group was 10% and 4% respectively. At Azariq the seven to thirteen age-group gave a spleen rate of 33% and a parasite rate of 11.9% (see Appendix 6). The two bloods with parasites at Zubeid School were scanty infections; of the five infected bloods at Azariq three were scanty, one moderate and one heavy infections. The parasite was Plasmodium falciparum in all cases.

It has been suggested, Gillies (1957), that in the absence of suitable conditions for A. gambiae, A. sergenti might maintain transmission at a low level until such time as A. gambiae could again thrive. The possibility that the Dhala area might reflect this situation was considered, especially as Dr Hunter had found A. gambiae in knock-downs in Figara (west of Dhala, near the Yemen border) and Azariq, and we had not found it at all only one month later (we were, in fact, unable to visit Figara). However, in spite of finding A. sergenti larvae in one isolated spot, malaria would seem to be, in the main, seasonal with A. gambiae as the vector during the wet and warm months. Knockdown spray catches were attempted in rocky caves in the Wadi El Khumeira, in order to find resting adults of A. sergenti, but they were never found. Apart from the A. gambiae found by Dr Hunter in October, 1962, there is no recent record of anophelines.

Lodar and Mukeiras (Maps 5 and 6)

The town of Lodar and its immediate vicinity had no natural breeding places, and the wells, static tanks and mosque tanks were negative. The main breeding place (almost the only one), several miles to the west, seemed to be the Wadi Arfan where there was about a mile (1.6 km) of slow-running water with many stationary pools and long stretches of imperceptibly moving water by the banks. The river bed was both rocky and muddy. Larvae and pupae of A. gambiae, A. dthali and A. turkhudi were taken here.

Not far from the Wadi Arfan and close to the village of Megel, was a narrow, almost dry, wadi with a few pools in which A. gambiae and A. dthali larvae were found. These pools seemed very "salty" but subsequent information indicates that the salts were more likely to be calcium than sodium. Knockdown spray catches in Megel village yielded nothing, but in nearby Bazileffa village, A. gambiae, A. dthali and A. cinereus were found in one house, and in the cattle quarters attached to the same house, A. gambiae, A. dthali and A. turkhudi were taken.

The spleen and bloods of 22 children in the one to twelve age-group were examined at Megel. The spleen rate was 27% and there were no infected bloods. However, of three individuals aged 60, 7 and 1 year, who had fevers at the time of our visit, the older two had moderate infections of P. falciparum (see Appendix 6).

Other villages nearer to Lodar were examined but no anophelines were found. At Amshaa, in the six to eleven age-group, a spleen rate of 2.5% was found with one scanty infection of P. falciparum giving a parasite rate also of 2.5% (see Appendix 6).

Malaria in the Lodar district, like Dhala, is primarily seasonal, but there is at least one village which could be a continuous source of infection in proximity to, what seems to be, a permanent breeding place of A. gambiae.

North-west of Lodar and 3000 feet (915 m) up on a plateau, is the town of Mukeiras. Many wells, mosque tanks and two wadis in the area were examined. Only in the Wadi Am Soloul, a somewhat picturesque, grassy stream, were two anophelines found: A. demeilloni and A. coustani. Knockdown spray catches were tried in a village on a hill overlooking this wadi, but no anophelines were seen. Gillies (1957) recorded the finding of A. sergenti, A. demeilloni, A. dthali and A. cinereus from the Mukeiras area.

On the way to Lodar and about 15 miles (24 km) south of it, a small town, Amwadhia, was surveyed. This place is very isolated and situated in the middle of a dry plain hemmed in by hills. A thorough search revealed no natural water source at all. Water requirements were met by means of a diesel engine which pumped water from a well into a static tank at regular intervals. The system seemed to present no opportunity for mosquito breeding. Some of the mud-covered stone houses were examined and knockdown spray catches attempted, but no mosquitos were found.

Spleens and bloods of children in the seven to fifteen age-group were examined. There was a spleen rate of 2.5% and a parasite rate of 1.2% (see Appendix 6). The one infected blood was a very scanty infection of Plasmodium falciparum.

Mukalla (Maps 7 and 8)

About 60 miles (96 km) west of Mukalla, on the coast where the Wadi Hajr meets the sea, is Meifa Hajr, the site of a new irrigation scheme and allegedly one of the most malarious places in the Quaiti coastal strip. In a marsh near Meifa, A. dthali larvae and pupae were found. About four miles (6.5 km) up the Wadi Hajr, at the side of the village of Al Hillah, larvae of A. dthali and A. demeilloni were collected from the many stony pools and rush-surrounded pools at the side of the running streams. Two out of three knockdown spray catches in Al Hillah yielded A. gambiae in moderate numbers, and A. dthali.

Spleens and bloods were examined in Meifa School, and in the age-group seven to sixteen, the spleen rate was 25% and parasite rate 12.5% (see Appendix 6). Of the six infected bloods, five were scanty and one was a moderate infection of P. falciparum.

There is high endemicity in the Meifa Hajr area and all the indications point to continuous transmission. The Wadi Hajr at Al Hillah, for example, had much running water which, it was reported, seldom dries up. A. gambiae larvae were not found here, but the numerous pools, large and small, scattered over the very wide river bed perhaps for some miles to the north and south, precluded a complete examination. Gorged females of A. gambiae were found in two out of the three houses examined.

Nearer to Mukalla and on the coast, the town of Fuwwa was visited. No breeding places were found in the immediate vicinity but, about four miles (6.5 km) or so up the Wadi Fuwwa and from there on for two or three miles (3-5 km) to Kherba village, there was a good deal of running water with many rocky and grassy pools in which larvae and pupae of A. sergenti and A. dthali were found. In Kherba itself, there is an extensive irrigation system, watered from the wadi, for the date palms, bananas and vegetables which grow there. More larvae and pupae of A. dthali were taken in the more permanent of the grassy streams of this system. Some knockdown spray catches were attempted in Kherba, but they were negative. Gillies (1957) found A. gambiae and A. dthali in both Kherba and Fuwwa.

The spleens and bloods of 45 children in the eight to ten age-group were examined at Fuwwa School. The spleen rate was 13.3% and the parasite rate 8.9% (see Appendix 6). Of the four positive bloods, two were scanty infections of P. falciparum and two moderate infections of P. vivax.

Both Fuwwa and Kherba are said to be endemic foci but malaria is probably mostly seasonal. We found no A. gambiae at the beginning of December, but Gillies (1957) found plenty about the 20 October five years earlier. It is worth noting that the owners of the gardens and their households abandon Kherba as soon as the date crop is in (end of September) and return to Fuwwa. When we were there the village was almost deserted and most of the houses were locked and empty.

Inland, north-west of Mukalla, the Wadi Aees yielded many larvae and pupae of A. dthali, but several knockdown spray catches in Aees village produced only culicines. A pool in a small plantation at the village of Harsheeat had larvae of A. sergenti and A. dthali in moderate numbers. More larvae and pupae of A. dthali were collected at a nearby bathing pool. Malaria here is reported to be seasonal, but our own evidence is very vague.

To the north-east of Mukalla are a number of villages, two of which were partially examined (Meihan El Museid and Tebaleh). A. dthali larvae and pupae were collected from an irrigation ditch which almost encircled the gardens of Meihan El Museid. Three knockdown spray catches in houses (two human and one chicken) produced only a few culicines. Of ten children, aged seven to fourteen, examined one had an enlarged spleen and all ten blood films were negative. In

Tebaleh again, the nearby wadi produced larvae and pupae of A. dthali. Like Aees and Harsheeat, there was no evidence of transmission in these areas when we were there, and any malaria would seem to be strictly seasonal.

Some 60 miles (96 km) or so east of Mukalla, on the coast is Hami. Malaria seems not to occur here, but the place was the limit of our examination of the country to the east. It is worth mentioning that Gillies (1957) had found a number of mosquito larvae and pupae breeding in "salt" encrusted pools in the vicinity. The adult resembled A. dthali but the larvae did not and, until it was described by Bailly-Choumara in 1960, it was referred to as the "saline mosquito". We, too, found this mosquito breeding in, no doubt, the same pools that were visited by Gillies in 1957 at Hami, and by the side of the road near Shihr. It completely fits Bailly-Choumara's description for A. azaniae. Water from these pools contains 2.5 parts of sodium chloride per thousand at Hami, and up to 7.6 parts at Shihr. No tests were made for calcium salt. Anopheles azaniae is of no medical importance and is said not to bite man. In other areas it has been found breeding in pools rich in calcium sulphate and chloride. A. dthali was also found breeding in an irrigation pool in a garden just north of Hami.

The Wadi Hadhramaut (Map 9)

The towns of Hajerayn and Haura in the Wadi Duan, a branch of the Wadi Hadhramaut, were examined. No natural breeding places were found and the wells and mosque bathing places, which were tested, were negative. Similarly, several knock-down spray catches attempted in both places yielded no anophelines.

At Hajerayn School, of 59 children in the six to thirteen age-group only one spleen was found to be positive and all bloods negative. At Haura, of 52 children in the seven to eleven age-group one child had a slightly enlarged spleen and all bloods were negative.

Some 50 miles (80 km) north-east of Haura and in the Wadi Hadhramaut proper, lies the fairly large town of Shibam. Like many of the towns and villages in the Wadi Hadhramaut system, Shibam experiences malaria whenever there is a flood in the local wadis after rain. There was no flood when we were there, but we saw the last semi-natural breeding place in the form of a small pond contained by the irrigation system of the gardens. The pond only had culicines. From a rocky pool on the

side of a hill overlooking Shibam, a number of anopheline larvae were collected, all of which proved to be A. rhodesiensis rupicolus. Several knockdown spray catches were tried but all were negative.

Of 68 children in the age-group seven to sixteen in the nearby school at Kheshamer, only one had a positive spleen and no bloods were positive of 21 examined. At Shibam we were shown evidence in the form of positive P. falciparum blood slides of an outbreak of malaria in the locality about one month before our visit.

About 10 miles (16 km) east of Shibam is Seiyun, the principal town of the area. There were no breeding places found in this area.

South-east of Seiyun, and about 45 miles (72 km) distant, lies the small town of Sah which is reputed to be fairly frequently affected by flood water and, in consequence, malaria. A fairly broad wadi ran through the extensive gardens of Sah but it was dry at this point when we were there. However, two disused wells yielded larvae of A. rhodesiensis rupicolus and A. sergenti. A small wadi (Wadi Arkh) about five miles (8 km) north of Sah had many larvae of A. dthali. Knock-down spray catches in houses in Sah only produced a few culicines.

In Sah School, 61 children in the age-group four to ten were examined, and they gave a spleen rate of 19.6%. Blood films from 43 of these children gave a parasite rate of 9.3% (see Appendix 6). Of the four positive bloods, one was a scanty, one a moderate and two were heavy infections of P. falciparum.

Ten miles (16 km) to the north of Sah and to the east of the road, the Wadi Gheil Ben Omer fringes the gardens of the village of Al Urd. At this point, when we were there, the wadi was freely flowing with swift and slow currents and falls, with many pools and backwaters. Larvae of A. fluviatilis, A. sergenti and A. dthali were found there. Knockdown spray catches in the nearby village of Al Urd produced A. sergenti and A. fluviatilis in considerable numbers from a cattle stall and in scanty numbers from adjoining human quarters. A. fluviatilis is a vector of malaria in the subcontinent of India and Iran. It is believed that this is the first record of it being found so far west.

Breeding places between and around the towns of Tarim and Qassem were very scarce. Some small unidentified anophelines were found in some pools near the road between Tarim and Qassem, and a small wadi with salty pools yielded many larvae and pupae of A. azaniae.

Of 56 children in the seven to twelve age-group at Qassem School, only one child had a positive spleen and he had only been in the country six months since arriving from Uganda. No positives were found in the 40 bloods examined.

A few miles east of Qassem the small village of Khon and the wadi which irrigates its gardens were examined. Larvae of A. dthali were found in the wadi. Knockdown spray catches in human and animal quarters produced several A. dthali, and one A. fluviatilis (from cattle shed). A night catch with human and cow bait produced three mosquitos, two A. turkudi and one A. sergenti, biting man. This night catch was done near the water where only larvae of A. dthali were found.

Socotra

One of us (M. J. Colbourne) paid a brief visit to the island of Socotra. In the few hours available little could be done, but larvae and pupae of A. dthali were found in pools in a stony river bed. Four boys were examined and two of them had positive spleens and the blood of one showed a moderate infection of Plasmodium falciparum.

DISCUSSION

The present investigation has confirmed that there is an important malaria problem in the Aden Protectorate.

In large parts of the cotton growing areas of Abyan and Lahej there is continuous malaria transmission. In parts of these areas about 20% of the children in school have parasites in their blood. Although these children may develop a degree of resistance this is not enough to prevent frequent clinical attacks of malaria in adults. This amount of sickness must interfere with the productivity of the people in these important areas.

Similar is the incidence of malaria in Meifa Hadjr, the site of a new irrigation system. It is easy to predict that the 2000 immigrants expected will be subject to the severe and fatal malaria that marked the inception of the Abyan scheme, unless preventive action is taken. Those working on construction at the moment are relatively immune as they are either local people or were brought from Abyan,

Recently there have been outbreaks of malaria in the Hadhramaut (about 1000 cases in Shibam in 1962). These outbreaks occur just at the time when the maximum energy is required from the farming community to take advantage of the infrequent rains.

We have already stressed the risk of malaria epidemics in other parts of the Protectorate.

It should not be thought that the Protectorate Health Service has not recognized these problems. The antimalarial measures described above have been planned to prevent malaria. If these measures had been carried out as planned most of the malaria would have been prevented. Why have they failed? There seems to us to have been two main reasons. First, no central malaria authority was responsible for planning ahead the programme for the year and for ensuring that supplies were available. Too much reliance was placed on the health assistants in charge of the mobile units themselves, and on the medical officers responsible for their direction. The latter had little experience of antimalarial work and also had heavy clinical responsibility. Secondly, no provision has been made for the assessment of the antimalarial work; assessment is required both of the work itself to ensure that it is carried out as planned and also, independently, of the incidence of malaria to ensure that antimalarial operations are achieving the expected results.

The idea of preventing malaria seems to have been lost, the emphasis has shifted to using preventive measures for dealing with outbreaks as they occur.

In the section on recommendations we suggest methods of overcoming these difficulties. There are, however, various points of special interest that require discussion: namely, the case for larviciding, the choice of insecticide, the problem of transmission by Anopheles sergenti, the place of the health assistant in malaria control, malaria in Aden Colony and malaria in Socotra.

Choice of Method

Larviciding is a possible alternative to house spraying with residual insecticides. In Abyan it was suggested to us that larviciding was the method of choice. This was natural as many had had experience of the successful campaign carried out by Qaid Salan and compared it with the present campaign with residual insecticides

which controlled effectively neither the malaria nor the mosquitos. The real comparison should be between a campaign that was very effectively carried out and one that, for various reasons, has never operated exactly according to plan.

The great advantage of the residual insecticides is their relatively low cost. The larviciding scheme in Abyan is said to have cost £ 10 000 (US$ 28 000) a year. It should be possible to provide protection with residual insecticides for the 20 000 people in Abyan for less than a quarter of this amount. It does not seem that the cost of larviciding could be much reduced, though there might be some saving on the cost of the larvicide itself. It has not been possible to identify exactly which larvicide was used but, from the cost quoted, it was probably Malariol HS with DDT. It may have been used too liberally, as though it was ordinary Malariol. It would be difficult to improve on the success achieved by Qaid Salan in covering 40 000 acres with eight spraymen. (This involves each man being responsible for an area of nearly 5000 acres to be covered each week, i.e. nearly 1000 acres a day.) Nowadays, it might be necessary to increase the labour force.

The use of residual insecticides for house spraying must be recommended as the antimalarial method of choice in Abyan as elsewhere in the Protectorate, unless other sources of funds, such as the people of Abyan themselves, are prepared to contribute to defray this additional cost of larviciding, in order to reduce mosquito nuisance.

There does, however, seem a good argument for a limited attack on mosquito breeding. During our visit it was always possible to collect an unlimited supply of A. gambiae larvae from within half a mile of Makhzan hospital. They were breeding in pools of water that had collected near earthworks in connexion with the irrigation of the cotton fields. If the mobile sanitary unit were kept informed of such work the breeding could easily be prevented. It is understood that the Abyan Cotton Board has always shown itself most co-operative in providing waste oil for larviciding. It might be possible for the Board's own operators to oil the pools that they unavoidably make in the beds of the wadis when using earth moving equipment. Such limited larviciding would not, of course, prevent transmission of malaria in Abyan, but it might well reduce it.

A trial of larviciding could usefully be carried out in a limited area, such as Abyan or Meifa Hadjr irrigation area, in order to see whether the cost would be reduced by a more economical larvicide. It would not be possible to carry out a useful trial before the formation of a malaria unit.

As we have been able to find sites of anopheline breeding scattered widely through rather inaccessible country, larviciding is unlikely to be a useful general method of control throughout the Protectorate.

The decision not to recommend larviciding as an important method of controlling malaria does not mean that there is no need to prevent the breeding of nuisance mosquitos in urban areas. In Lahej in particular there was obvious and easily preventable mosquito breeding both in Lahef town itself and Dar-Sad. Many people complained to us of the nuisance caused by these mosquitos. They were found to be mainly Aedes and easily controllable.

Residual Insecticides

The present antimalarial operations are based on the use of BHC, 50% γ-isomer. Its advantages are its low cost (though frequent application increases labour costs if a small dose is used), and its non-toxicity to mammals. It has some advantage over DDT when used on mud walls, although DDT is now the insecticide used in most WHO-supported campaigns in Africa, where A. gambiae is the vector. The disadvantage of BHC is its relatively short residual effect and the tendency of A. gambiae to become resistant to the BHC/dieldrin group of insecticides (although no such resistance has yet been reported from East Africa). The susceptibility tests carried out by us in Abyan suggest that there has been no development of resistance to BHC in Aden. (See Appendix 7.)

The decision with regard to the choice of insecticide is not an easy one. The present antimalarial teams are used to BHC; it is very suitable for obtaining a quick control of anopheline if applied directly after floods have led to the formation of anopheline breeding places (as we have recommended in the Hadhramaut). There are arguments in favour of reserving DDT for an all-out campaign to eradicate malaria when the time is ripe. On the other hand, if attempts are to be made to give protection by spraying houses just before the malaria transmission season starts, as would seem practical in many parts of the Federation and in the coastal areas of the Eastern Aden Protectorate, the longer residual effect of DDT would be a great advantage.

We have reached the conclusion that, taking these conflicting factors into account, it would be better not to change from BHC at the moment. When a malaria unit has been set up and it becomes possible to assess the effective life of the insecticides under local conditions in the Protectorate, this conclusion may be reconsidered. For the moment it seems better to concentrate on getting the teams to make the best use of the insecticide they already know. Some of the disadvantages of BHC can be overcome by increasing the dose.

Timing of Spraying

Most of those responsible for spraying operations understood the need for correct timing; that is, sufficiently often to produce a continuously insecticidal surface where transmission is continuous; just before anopheline breeding starts where this is predictable; just after rainfalls or floods occur in the unpredictable areas, such as the Hadhramaut.

In practically no place was this plan carried out. The reasons were usually shortage of BHC which made a planned operation impossible; contrary instruction from local authorities who wished the available BHC to be used for fly control or public relations purposes, or misapprehension of the reasons for the use of residual insecticides which resulted in only a few important buildings in an area being sprayed.

To ensure correct timing it seems necessary to decide centrally how much BHC is to be made available each year in the Eastern and the Western Protectorates, plan its use and then carry out the plan, always keeping in reserve a sufficient amount for dealing with epidemics which are certain to occur if the expected break in the present succession of dry years occurs.

Dosage of Insecticide

We have observed the widest variation in the dosage of insecticide used; this has arisen partly from a misinterpretation of instructions and partly from a failure to realize that a change in the formulation used may result in a change of the dosage. There are advantages of simplicity in merely giving an instruction that a fixed amount of powder should be used in a fixed amount of water, but those in charge of spraying squads should understand that the effective dose on the wall depends on the strength of the formulation, the output of the pump and the spraying rhythm.

We recommend a dosage of 40 mg gamma-isomer of BHC per square foot (0.43 g/m^2). This can only be turned into an instruction to use 3 oz (85 g) of a 50% gamma-isomer water dispersible powder in a gallon of water (4.5 l), provided that checks show that this amount is applied to 1000 square feet (93 m^2). In spite of the inaccuracies of volumetric measurement it is not suggested that the present teams should change to a gravimetric method. It is important, however, to check that the measures used are approximately accurate. It is a fallacy to believe that an ounce (28 g) of 50% BHC powder will necessarily occupy the same space as an ounce (28 g) of tuna fish or tomato purée.

It should be noted that the dosage now recommended (40 mg gamma-isomer per square foot (0.43 g/m^2)) is considerably higher than the one in general use when antimalarial operations were first started in the Protectorate. It has the advantage of a longer action, especially on mud walls. It should be used twice a year in the areas where transmission is continuous but only once a year in the rest of the country, provided that spraying is correctly timed. This should provide good control; when an assessment team has been set up it will be necessary to confirm that this dosage and timing is correct.

Trials are in progress in Abyan with chlorinated hydrocarbons as a measure against pests of cotton. It seems that they would be used only for a short time each year and would be unlikely to come into contact with anopheline larvae. The health service should find out which insecticides are being used and any changes in techniques, as it may have some bearing on choice of future insecticides for anti-malarial work.

The Role of Anopheles sergenti and A. fluviatilis as Vectors

One of the more important technical problems facing malaria control in the Aden Protectorate is to estimate the importance of A. sergenti as a vector. It has been known to occur in the Protectorate for many years. In some parts of Arabia it is easy to control by house spraying with residual insecticides, but in others where it can rest outside in rocky caves larviciding has been found necessary.

In the Aden Protectorate it seems that along the coast A. gambiae is the only important vector. There are three or four areas where A. sergenti has been found: in the central inland area from Beihan to Yeshbum, by Gillies in 1957 (we did not

visit this area and can comment on it no further); around Mukeiras where it was found by Gillies but not by us (in any case, this is an area where malaria is of little, if any, importance); near Dhala where it seems less likely to be a vector than A. gambiae; at Kherba and Harsheeat, in the Mukalla area, by us, where again the available evidence suggests that A. gambiae is likely to be the vector; in the Wadi Hadhramaut by us and by Merucei and Hoeok (Mattingly & Knight, 1956) and, unexpectedly, by us at Bateis.

Our observations have suggested that A. sergenti bites outside and prefers to rest in cow sheds. There is strong circumstantial evidence that A. sergenti is responsible for the malaria outbreaks in the Wadi Hadhramaut and that it is well controlled by residual insecticides under these conditions. It is uncertain how far this low grade continuous transmission around the wadi at places such as Khon and Sah would be controlled by residual insecticides. The part played by A. sergenti in the high-level malaria transmission at Bateis is also unknown.

The occurrence of A. fluviatilis, too, presents a minor problem. This mosquito was found at Al Urd and then at Khon, some 50 miles (80 km) to the north-east. It is a vector of some importance in parts of the Indian subcontinent and Iran, and, as far as we are aware, it has never before been recorded from anywhere within the Aden Protectorate. It cannot be excluded as a possible vector, although our own information leads us to believe that it is not as widespread in the Hadhramaut as A. sergenti. The breeding places and feeding habits of fluviatilis are somewhat similar to those of sergenti, and control measures for the one will be suitable for the other.

There are, therefore, several subjects that require investigation. One, requiring immediate study, is the identification of the anophelines, assumed by us to be A. sergenti, that are present in enormous numbers during malaria outbreaks in the towns of the Wadi Hadhramaut.

Other subjects which will require continuous observation must await the setting up of a malaria service with an investigation unit. These include obtaining answers to such questions as: Will residual insecticides control transmission at places such as Sah and Khon? Should cattle sheds be sprayed? Is A. sergenti the

the important vector in the Dhala and Beihan-Yeshbum area? What are its habits? What is the importance of the presence of A. sergenti at Bateis? Does residual spraying there completely interrupt transmission?

In the meantime, there is no doubt that house spraying with residual insecticides will control practically all the malaria transmission occurring in the Protectorate.

The Place of the Health Assistant in the Control of Malaria

In the antimalarial operations currently carried out the health assistant in charge of the health unit plays a major part. He is provided with a compression sprayer and, when available, insecticide, and he is largely responsible for prevention of malaria in his district. During his training he has received instruction on antimalarial operations from the health assistant in charge of the mobile sanitary unit in Abyan or Mukalla.

If he is in an area where the period of transmission can be forecast he is to spray just before mosquito breeding is expected to start. If in an area where no forecast can be made, he should spray directly breeding places that are produced by rain or flood.

Practically nowhere was this plan found to be actually in operation. Supplies of insecticide were quite irregular and practically none of the health assistants knew how much insecticide they required to give total coverage to their districts. Most of them knew what should be done in theory, but practical questioning and observation showed that some of them knew little about their equipment and how to use it. It seems to be asking too much of the health assistant, who has so many responsibilities, to expect him to maintain a sufficiently good knowledge of spraying methods to enable him quickly to train spraymen during the emergency of a malaria outbreak. A few calculations showed that even with their equipment working properly and with enough insecticide available, it would take three to five months for the health assistant's one sprayer to cover all the houses in his district. In the places where efficient health assistants had equipment and supplies available, they were subject to outside local influence to spray houses for reasons that had nothing to do with the control of malaria.

This rather gloomy picture was relieved by the fact that there were several health assistants (e.g. in Lodar) who had a clear idea of what could be done and were carrying it out. From their clinical work they recognized that there were only a few foci of continuing local transmission in their district and were dealing with these efficiently.

It is felt that, as a rule, it is impracticable for those with clinical responsibilities to undertake routine antimalarial measures and we are recommending that practically all spraying should be done by the mobile sanitary units. This does not mean that the health assistants have no part to play in malaria control. In the early stages their knowledge of the locality and the timing of malaria transmission is invaluable; in the later stages of eradication they will be the backbone of the system of finding and treating of residual cases. If an epidemic occurs during the next few years it will be the local health assistant who will have the first responsibility of dealing with it. For all these reasons it is essential that the health assistant should still be recognized as playing an important part in malaria control, but that his part should be replanned.

It is necessary to define those health units where spraying is likely to be required and which cannot be covered by the mobile sanitary unit. These units should be provided with efficient sprayers and sufficient insecticide to be used only in clearly specified conditions, and the health assistant must be given clear instructions on how to spray properly. There is no need for the other units to be provided with spraying equipment and it should be withdrawn for overhaul and re-issue where required.

It is suggested that such a survey and redistribution of equipment should be one of the duties of the new health inspector.

It is possible that a year of heavy rains might result in a widespread malaria outbreak with which the mobile sanitary units could not deal. It is suggested that a reserve of antimalarial drugs be kept in each health unit with instruction on their use.

Malaria in Aden Colony

Although our assignment was limited to the problem of malaria in Aden Protectorate, the problem of malaria in Aden Colony was also discussed.

Malaria is reported as having been eradicated from Aden Colony: this has been accomplished by well-organized larviciding which is checked by an efficient "larva spotter" who has, on frequent occasions, found anopheline larvae breeding in wells and garden irrigation tanks on the outskirts of Sheikh Othman. Another area in the Colony where difficulties have been encountered is the village of Hiswa.

Sheikh Othman is in a position of particular difficulty as it touches the boundary of the Federation and is, in part, continuous with Dar-Sad, a village in the state of Lahej. Dar-Sad is separated from any other centres of habitation in the Federation by several miles of desert. There is a similar close relationship between the village of Hiswa in the Colony and Al Ittihad in the Federation.

From the point of view of the prevention of malaria, it is clear that Al Ittihad and Dar-Sad should be tr ated with Aden Colony.

There is no doubt that in the relatively small, heavily populated Colony (even with the addition of Dar-Sad and Al Ittihad) malaria eradication can be maintained by efficient larviciding. This should become administratively easier when the merger of the Colony and the Federation takes place.

A very high degree of efficiency will have to be maintained as there will be a parasite reservoir in the Colony for many years to come. Our surveys have shown that visitors from many parts of the Protectorate, both East and West, are liable to be gametocyte carriers. There seems little doubt that a few cases of indigenous malaria have occurred in the Colony in recent years.

In view of its special relations with the Colony, an attempt was made to assess the importance of the parasite reservoir in Dar-Sad. Blood films were taken by a technician from 30 women and children attending a welfare clinic and judged by the sister in charge to be possible cases of malaria. They were all negative.

Yemeni Immigrants

It was suggested to us that an important reservoir of parasites could be found in the immigrants into Aden from the Yemen. According to the Lahej State Customs Authorities these immigrants number about 26 000 a year.

Accordingly blood films were taken in November, 1962, from 106 Yemeni immigrants as they passed through the Lahej customs post. Of these 106, 18 had never visited Aden before; eight had not visited it for more than one year; the others, including the drivers and their mates, had visited more recently. The group who usually lived in Aden but had just returned from the Yemen was unusually swollen by the political situation; many had made a quick trip to the Yemen to visit their families after the change of government and were returning to work in Aden. Amongst the group of 106, four positive blood films were found. Two were moderately heavy infections in children who had not visited Aden before. The two other infections were very slight ones in the group who had only visited the Yemen briefly. Unfortunately, it was not possible to confirm that the positive blood films were from the drivers and their mates, who are the most likely parasite carriers in this group.

These figures may seem unexpectedly low but, considering the large number of immigrants, they represent a considerable importation of parasites into the Colony - though no more important than that of groups coming from heavily infected parts of the Protectorate.

Malaria in Socotra

The island of Socotra is politically a part of the East Aden Protectorate that is not yet administered. It lies about 300 miles (480 km) south-east of Mukalla, measures about 70 miles (113 km) by 20 miles (32 km), and has a population of about 6000. The population lives in villages scattered through the island. There is an airstrip, but no regular air services; ordinarily communications with the outside world are by dhows which can only visit the island during the calm six months of the year.

One of us (M. J. Colbourne) was able to visit the island for a few hours as a guest of the Air Officer Commanding, Aden, who was making a routine visit to the island. During this short visit it was possible only to collect a few anopheline

larvae from a rocky stream bed at the edge of a village near the airport, and to examine four children (two of whom had enlarged spleens and one of whom had a moderate infection with Plasmodium falciparum).

Previous medical visitors have noted the high endemicity of malaria in the island, quoting a spleen rate of 60%. The only anophelines reported from the island are: Anopheles dthali and A. culicifacies adenensis. The few larvae collected by us proved to be A. dthali.

The eradication of malaria from such a remote island with a fairly small population should not be very difficult technically. A combined use of drugs and residual insecticides would probably be successful in a few years. Such a scheme would need careful planning and a much more complete knowledge of the people and their malaria than is available at the moment. It would probably need several months of careful explanation before popular co-operation could be achieved.

The staff required would probably be one medical officer and three or four assistants. This does not seem excessive if it were to result in the eradication of malaria, but it appears scarcely feasible with the present lack of communications with the outside world, and with the present lack of any administrative machinery - the only representatives of the central government on the island are two radio operators and one health assistant.

It should be remembered that the eradication of malaria would require maintenance, particularly as the islanders are in contact, by dhow, with the mainland of Africa more than the Aden Protectorate. (A representative of the Sultan of Socotra who was given a lift back to Aden by air was visiting the Protectorate for the first time, although he had already been to Mombasa and Dar-es-Salaam.) Such maintenance in the scattered villages of Socotra would require a much stronger administrative and health network than exists at the moment.

It seems that for the present no more can be done than to continue treatment of clinical cases and to take every opportunity to collect the information necessary for planning an antimalarial campaign in Socotra, whether it be aimed at control or eradication, so that it can be put into effect when the administrative situation improves. Unless this is done the continuation of this focus of endemic malaria may eventually become a threat to the rest of the Protectorate.

Public Relations

The success of many antimalarial campaigns has been impeded by deteriorating public relations. Although the reasons are usually quite obvious they are often not discovered until the damage has been done, and it is then very difficult to re-establish confidence that has been lost. A common course of events is for the early operations to be regarded with suspicion as being unfamiliar and disturbing; the first results of spraying are usually spectacular and a period of full co-operation is enjoyed; during the later years of the campaign the memory of malaria fades and there is often a return of nuisance arthropods. At this stage public reaction will vary from co-operation through apathy to hostility. Success in the later stages will depend largely on the care that has to be taken to develop good public relations in the early years of the campaign.

We gained the impression that the antimalarial operations in the Protectorate are now being carried out with reasonable co-operation from the public. In Abyan, it was reported that there was opposition to spraying in the towns of Gaar and Zingebar, but none in the villages. In the Eastern Aden Protectorate we were impressed by the care that was taken to provide the spraying teams with the correct introduction to the local authorities. Opposition was reported to be very low and little difficulty was experienced in spraying even the women's quarters.

In some towns fears were expressed that spraying might kill domesticated bees. This problem was discussed at some length and it seemed that trouble was likely only when badly trained spraymen were careless about the places to which they applied the insecticide.

It is worth noting that both the health assistants in charge of the mobile sanitary units were men of considerable personality. Their explanations were willingly accepted by local leaders; such qualities must be balanced against lack of technical ability and agility.

The methods that should be taken to ensure continued public co-operation are quite simple, but it is essential that they are understood by all taking part in antimalarial work, and that they are put into effect as soon as possible. If it is agreed that antimalarial work in the Protectorate requires to be reorganized, the new programme must be organized to ensure that full public co-operation is obtained.

A completely fresh approach is not possible as practically every part of the country has had several years experience of spraying operations. The objective should be to prevent any action that may lead to lack of co-operation in future years.

The first requirement is adequate information for the people living in areas that are to be sprayed. Most important is operational information; this must be given well before operations start and must be accurate. The timing of operations must be made to fit in with the wishes of the people. Equally important is provision of information about the objects and methods of the campaign. The techniques of spreading this information and the correct channels of communication are matters for local decision. Accuracy of the information provided is extremely important. It is useless to say that the object of the campaign is to kill mosquitos if there is every reason to believe that, in a few years, nuisance mosquitos will become resistant to the insecticide.

The second requirement is suitable training for the spraymen in how to deal with the public. This is essential as most members of the public will meet only one member of the antimalarial service, the sprayman. It is most important that the approach to the householder should show the tact of the health worker and not the authoritarianism of the policeman. This is not easy when the sprayman is often the lowest class of unskilled labour, unsure of himself in the presence of the householder who may be a person of some importance. The sprayman must be able to answer simple questions or be prepared to refer the questioner to someone who can answer. Incorrect answers may result in bizarre misunderstandings.

The health assistant in charge of the local health units can play an important part in establishing contact between the malaria unit and the local authorities, but it is unlikely that he will have sufficient experience of the techniques of spraying operations to be able to train spraymen in the correct approach to the public, or to explain the exact objects and methods of the campaign.

RECOMMENDATIONS

In the preceding pages we have described the nature of the malaria problem in the Aden Protectorate, the measures that are being taken to deal with it, and the results of our investigation. In this section we will suggest possible methods of dealing with the problem.

There appear to be two main alternatives: continuation of the present control operations, with minor changes to iron out the obvious deficiencies, or the more radical method of a campaign to eradicate malaria from the Protectorate. Although eradication is obviously preferable we do not think that it is yet practicable, and therefore recommend a programme of development in three stages.

First. An improvement of the present antimalarial work with the resources now available.

Second. The development and improvement of this work to achieve more efficient malaria control and, at the same time, to prepare for an operation to eradicate malaria.

Third. The planning and execution of a malaria eradication campaign.

The following reasons have led us to make these recommendations.

The present operations do not seem to have achieved the expected results for two main reasons - lack of central planning and the lack of regular and thorough assessment. Too much seems to have been left to the discretion of the local medical officer and health assistant. We have been very impressed by the efficiency of the junior medical staff in the field, but their clinical responsibilities are so heavy that without very clear instructions from the centre, preventive work is liable to be neglected.

Secondly, there is no mechanism for the assessment of the results of antimalarial work carried out, except the general one of its effect on the hospital and health unit returns. Without a rigid assessment much work is liable to be misdirected or wasted. Lack of funds or political pressure tends to alter the frequency or timing of antimalarial operations so that the operations that are carried out, still at considerable expense, achieve very little. Unless assessment is effective, the operations themselves may give a misleading appearance of efficiency.

The immediate implementation of a programme to eradicate malaria from the Protectorate appears superficially very attractive. Malaria has already been eradicated from Aden Colony: in most parts of the Protectorate malaria is unstable and transmission could probably be interrupted without much difficulty. There is already in operation an excellent system of health units covering most of the populated areas, far in advance of that found in most countries in a similar state of development.

But there are, at the moment, two very serious obstacles to the eradication of malaria. A considerable part of the Protectorate, some of which is certainly malarious, is not yet administered. Even though intermittent health work is carried out in these areas, it is not yet conceivable that operations could be carried out within these areas with the perfection needed for malaria eradication. In many of the areas already administered much preparatory organizational work would be required before an eradication operation could be undertaken; for example, in Lahej state the central government estimates the population to be 39 000; the state estimate is 90 000.

The second objection to an immediate plan for eradication is the very large movement of population between the Yemen and the Federation, amounting to about 26 000 a year. We have discussed the problem of malaria in the Yemen immigrants above; we consider that, even if only 3 or 4% of the immigrants are infected, this would place a very heavy burden on the consolidation phase in the Protectorate, unless effective operations are also carried on in the Yemen.

These difficulties seem to make an immediate eradication programme impracticable. They do not mean that it can never be undertaken. In fact, it is the obvious ultimate objective of antimalarial work in the Protectorate and it is suggested that this objective should be formally recognized as soon as possible. The technical and financial advantages of eradication over unending control are too well known to need repeating.

The continuation of malaria transmission in the Aden Protectorate might eventually become a threat to neighbouring countries; Saudi Arabia is already planning the implementation of malaria eradication; a WHO malariologist will be working in the Yemen in 1964 with the object of preparing for eventual eradication. It would be

extremely useful if a direct contact was established between the health services of the countries of Southern Arabia with the object of co-ordinating antimalarial activities. In other areas, such as Borneo and South-East Asia, inter-country co-ordination has been a very useful stimulus to antimalarial work.

To overcome these difficulties we recommend the development of antimalarial operations in three stages.

First stage. During the first stage, which should start immediately, it is suggested that improvement be made in the present operations without any major changes. Improvement should be limited to what can reasonably be expected of the staff at present available. This staff should include the recently recruited health inspector. Obvious immediate improvements are required in planning, technique and timing of antimalarial operations. No radical alterations are suggested in this stage.

We have been struck by one definite danger in the present situation. In the Federation there has been a succession of dry years, particularly in the Dhala and Lodar areas. A year of long continuing rain of moderate intensity would certainly result in a heavy incidence of malaria or even an epidemic (as has occurred before). It does not seem, at the moment, that there are adequate reserves available to deal with such a situation.

The health adviser should make recommendations to the head of each health service giving details of how antimalarial operations should be planned and carried out. This recommendation should also form the basis of training in antimalarial operations.

Second stage. The objectives of the second stage are to build up an efficient and economical system of controlling malaria in the Aden Protectorate and, at the same time, to develop the resources that are necessary before malaria eradication can be undertaken.

The main requirements are a malaria service under the control of a professional man who has had training in modern antimalarial methods and the development, within this service, of an investigation and assessment section whose objectives

would be to assess the efficiency with which operations are carried out and also to find practical solutions for local problems as they are encountered. The actual antimalarial operations would be carried out by the mobile sanitary units which are already established, or planned, by the individual health services. The malaria service would start on a small scale and would be expanded gradually until it eventually could be transformed into the malaria eradication service required to undertake the third stage.

The professional man mentioned above would be assisted, at least part-time, by the health inspector. The assessment section would consist of two technicians who would require training and who would both need to be able to carry out simple entomological techniques and to be competent in the collection and examination of blood films for malaria parasites.

The duties of the malaria service would include:

(i) A complete and continuing survey of the Protectorate to provide information about the intensity and timing of malaria transmission throughout the Protectorate.

(ii) The planning of rational spraying operations - a continuation of the start made in the first stage.

(iii) The training of the mobile sanitary units and assessment of their work. An agreement would have to be reached with the three health services to permit this to be done by a central unit.

(iv) Essential investigations, including; determination of the best insecticide and the correct dosage for use in the Protectorate; continuing observation on the susceptibility of the local vectors to residual insecticides; investigation into the importance of A. sergenti as a vector and its response to control with residual insecticides; and the practicability and cost of larviciding as a method of control in special circumstances.

(v) The collection of the information and development of the services required in planning malaria eradication. (See Manual on Preparation of Malaria Eradication Programmes, Division of Malaria Eradication, WHO, Geneva, July 1961, WHO/MEM/3.)

The key-man in this service will be the professional man in charge. There seem to be three possibilities of finding and training a suitable man for this post.

(i) To train one of the members of the present health service by sending him on a course. One of the malaria eradication courses run by WHO, lasting about three months, would be the most suitable. These are run regularly at either Lagos or Manila.

(ii) To establish a new post to be filled by a trained malariologist.

(iii) To apply to WHO to establish a malaria project in the Protectorate with the object of training local staff and preparing for malaria eradication.

In view of the difficulty of finding suitable trained malariologists and in view of the great advantage of continuity which can only be assured by the appointment to the post of a member of the country's health service, the training of a suitable man for the post seems preferable, provided there is a reasonable prospect of his remaining in the health service for some time. This would not preclude a simultaneous request for assistance from WHO.

In view of the comparatively small size of the malaria problem, in the Protectorate one professional man, with technical advice, as required, from outside, should be enough; but without one trained professional man little is likely to be accomplished.

It would also be advisable for the junior staff to attend one of the malaria courses in Arabic that are being run with assistance from WHO in the Eastern Mediterranean Region (in the Sudan, Jeddah or Cairo). The government could apply to WHO for the allocation of WHO fellowships to cover attendance at both the senior and junior courses.

We were asked whether such a malaria service would be able to undertake the responsibility for the control of other endemic diseases. It seems clear that in the early stages of its development it will not have the time or resources; later, either when malaria has been eradicated or even when it is well controlled the possibility of enlarging the malaria service to include the control of other important endemic diseases could be reconsidered.

There is one point that should be stressed from the beginning. Those engaged in antimalarial work should have no regular clinical responsibilities; this does not exclude the treatment by medically qualified personnel of minor sickness encountered on their visits to outlying districts. Such treatment is a useful measure for obtaining public support for antimalarial work. Even this limited medical work must not be allowed to interfere with the real object of the service - the efficient control of malaria. Regular clinical work, which must necessarily receive priority, is inconsistent with antimalarial work which demands carefully planned and timed operations.

Third stage. The initiation of a campaign to eradicate malaria from Aden Protectorate requires the fulfilment of certain criteria: demonstration that a satisfactory technical method is available; the organization, both administrative and technical, to carry it out; enough money; public understanding and acceptance of the objects and methods of malaria eradication; and integration with plans to eradicate from neighbouring countries.

It is obviously not possible to make any predictions as to when such a campaign could be started. The timing and the organization will depend on factors that at the moment are quite obscure. They can be approached gradually during stage 2, provided that those directing the work of the malaria service keep the ultimate objective of malaria eradication constantly in view.

The cost of the campaign cannot be forecast very accurately. The usual cost for eradication of about 3-4 shillings (42-56 US$) per head of the population for about eight years does not have much relevance to Aden, even if the population were accurately known.

There are certainly some areas where no transmission occurs and no action will be required; in other areas transmission is so infrequent or at such a low level that the attack phase can be omitted; effective control measures should increase the size of such areas. It will be one of the duties of the malaria service during stage 2 to define these areas where modified methods of eradication are required and at the same time to estimate the probable cost of eradication.

The future of the organization of the health services of the Protectorate is not very clear, but the present division into east and west would suggest the advantages of a central malaria service with control over two executive units each responsible for eradicating malaria from a population of about 400 000.

SUMMARY

Malaria constitutes an important health problem in the Aden Protectorates.

Malaria transmission continues throughout the year in several places of economic importance, such as the upper parts of the Abyan and Lahej irrigated areas and the Meifa Hajr area. There are other areas where transmission is to be expected at a low level seasonally each year. These areas are widely distributed throughout the Protectorates. Malaria epidemics are to be expected at irregular intervals over most of the rest of the Protectorates.

The most important vector seems to be A. gambiae; A. sergenti is probably responsible for most of the epidemic malaria. The importance of A. fluviatilis requires definition.

The present antimalarial operations are based on house spraying with benzene hexachloride, carried out mainly by the mobile sanitary units, but also by the out-station health assistants.

Lack of a clearly defined central malariological control and lack of an assessment mechanism, together with a shortage of supplies, has rendered these operations less effective than might have been hoped.

It is recommended that the antimalarial operations be reorganized in three stages.

First. The improvement of the present operations with the resources now available.

Second. The setting up of an antimalarial service to establish effective control operations and, at the same time, to make the preparations necessary to ensure that a malaria eradication campaign can be carried out successfully.

Third. The implementation of a malaria eradication campaign.

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FIG. 2

ABYAN

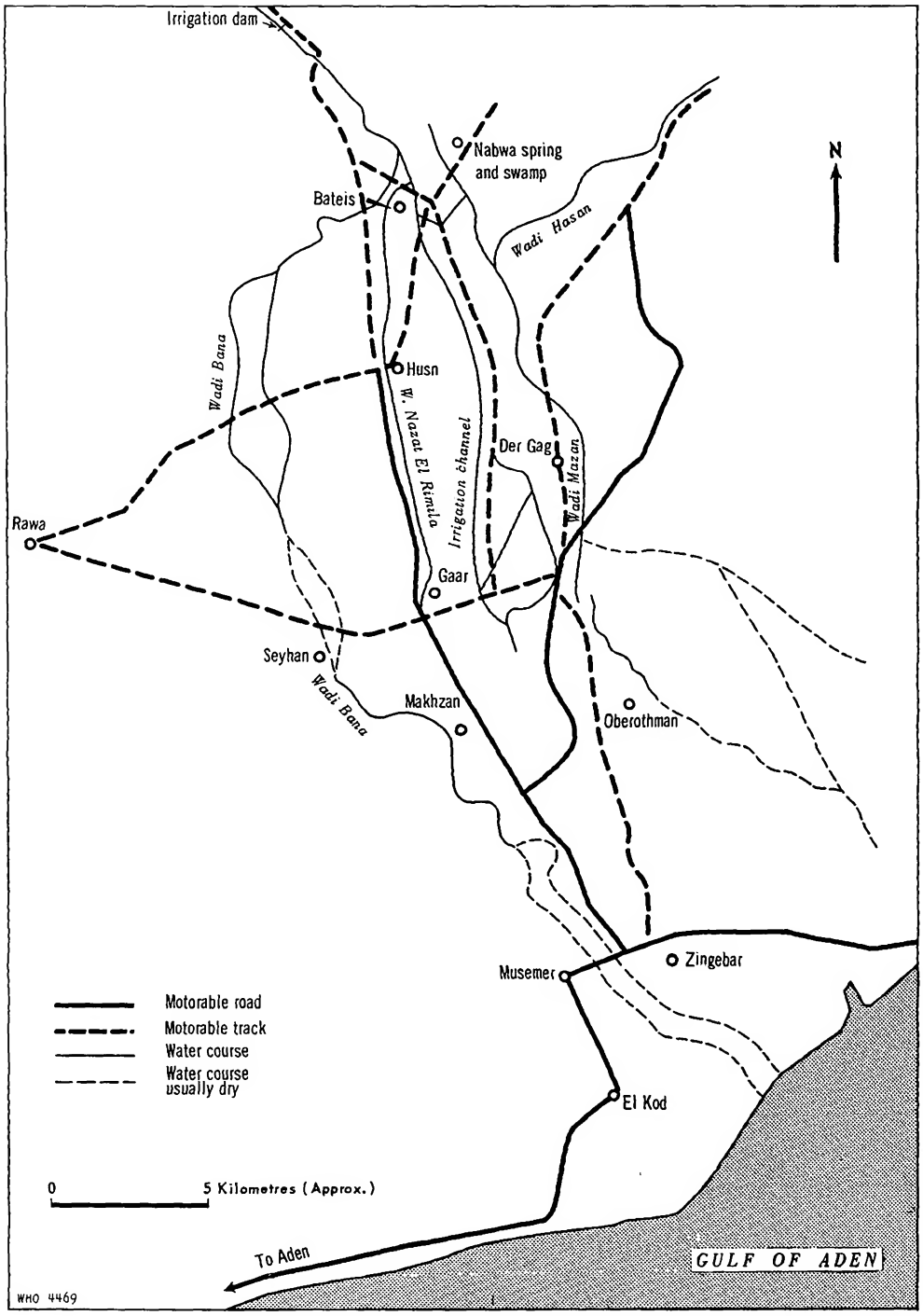

Irrigation dam
Nabwa spring and swamp
Bateis
Wadi Hasan
N
Wadi Bana
Husn
W. Nazal El Rimla
Irrigation channel
Der Gag
Wadi Mazan
Rawa
Gaar
Seyhan
Wadi Bana
Makhzan
Oberothman
Zingebar
Musemer
El Kod
Motorable road
Motorable track
Water course
Water course usually dry
0
5 Kilometres (Approx.)
To Aden
GULF OF ADEN
WHO 4469

FIG. 3

LAHEJ

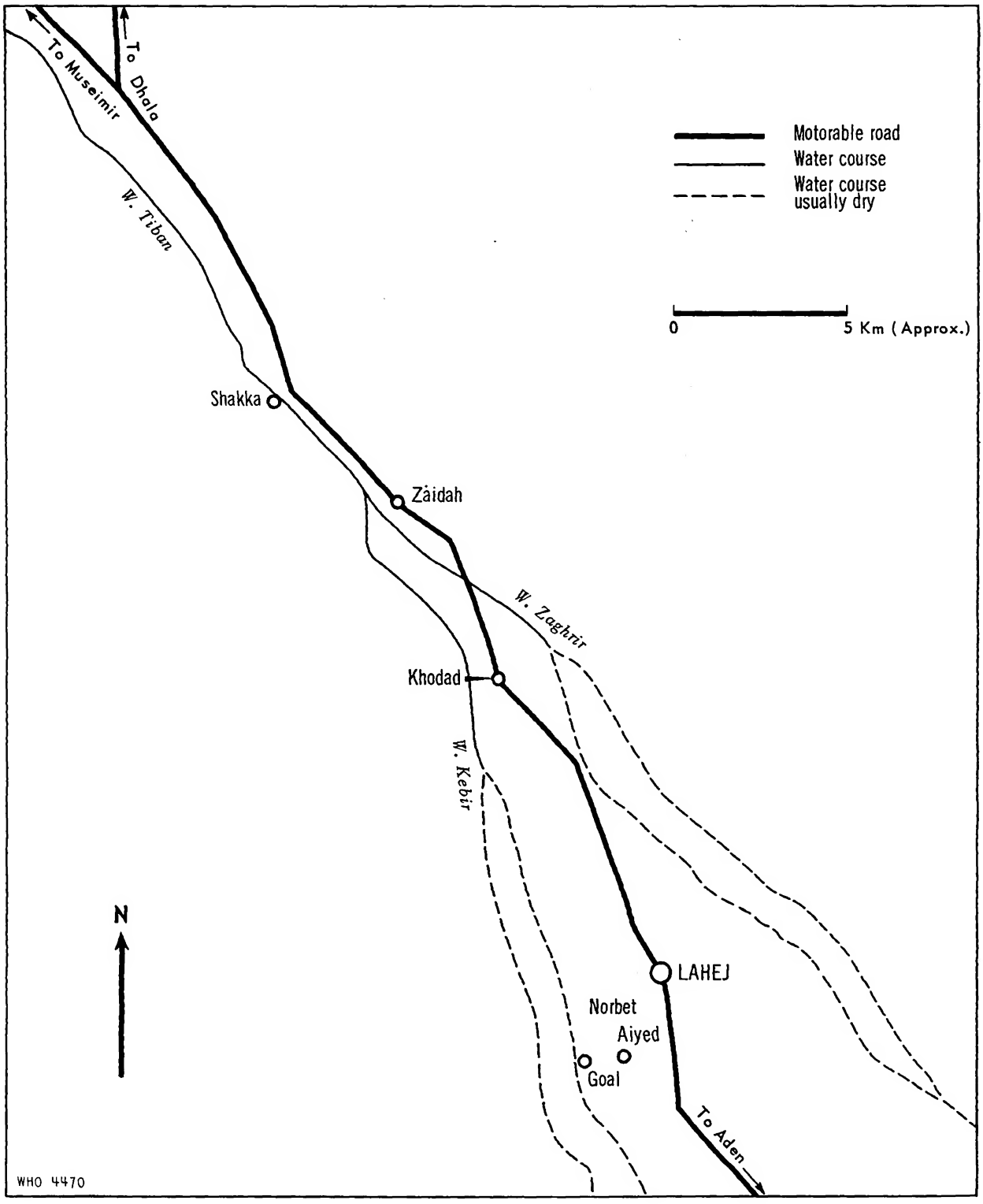

To Museimir
To Dhala
W. Tiban
Motorable road
Water course
Water course usually dry
0
5 Km (Approx.)
Shakka
Zàidah
W. Zaghir
Khodad
W. Kebir
N
LAHEJ
Norbet
Aiyed
Goal
To Aden
WHO 4470

FIG. 4

DHALA

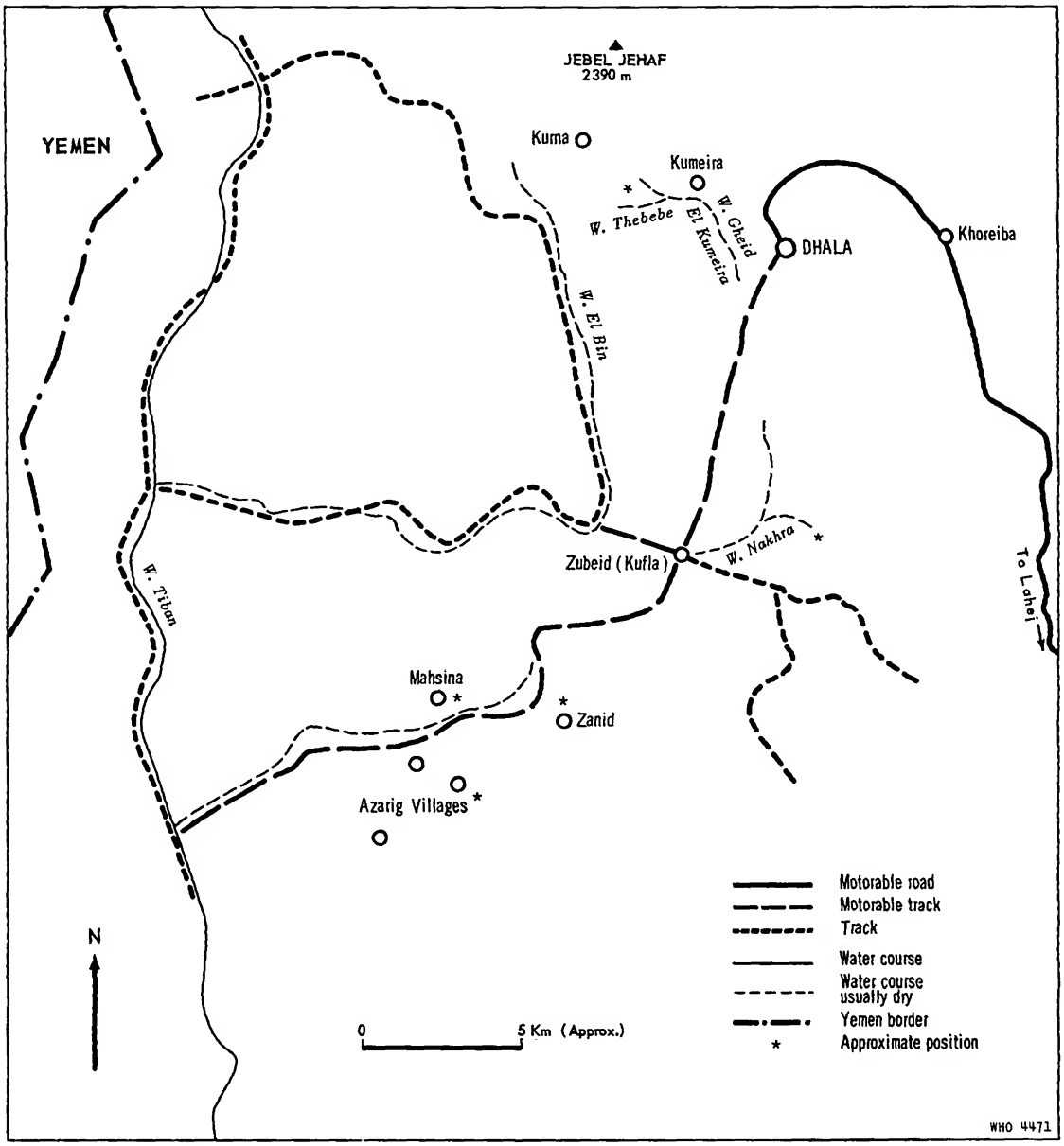

JEBEL JEHAF
2390 m
YEMEN
Kuma
Kumeira
W. Thebebe
El Kumeira
W. Cheid
DHALA
Khoreiba
W. El Bin
W. Nakhra
Zubeid (Kufla)
To Lahej
W. Tiban
Mahsina
Zanid
Azarig Villages
N
0
5 Km (Approx.)
Motorable road
Motorable track
Track
Water course
Water course usually dry
Yemen border
Approximate position
WHO 4471

FIG. 5

LODAR

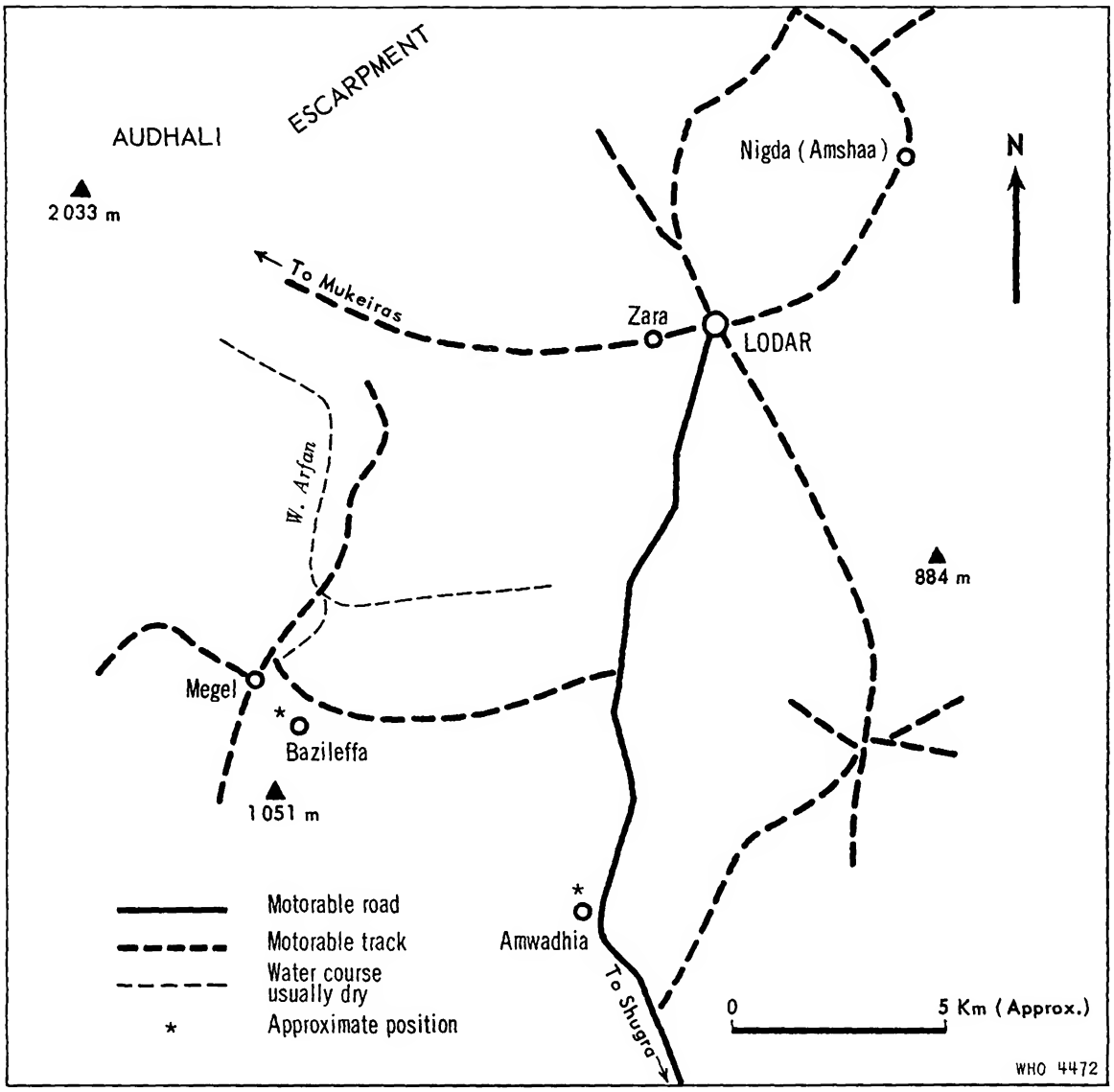

AUDHALI
ESCARPMENT
2033 m
Nigda (Amshaa)
N
To Mukeiras
Zara
LODAR
W. Arfan
884 m
Megel
Bazileffa
1051 m
Amwadhia
To Shugra
Motorable road
Motorable track
Water course usually dry
Approximate position
0
5 Km (Approx.)
WHO 4472

FIG. 6

MUKEIRAS

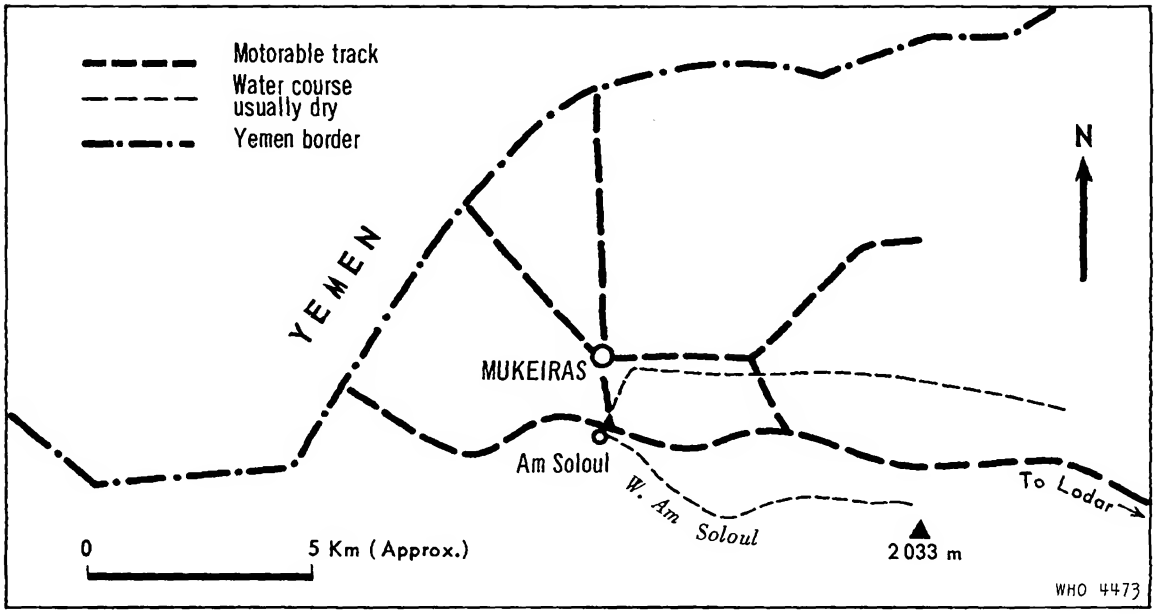


FIG. 7

MEIFA HAJR (MUKALLA)

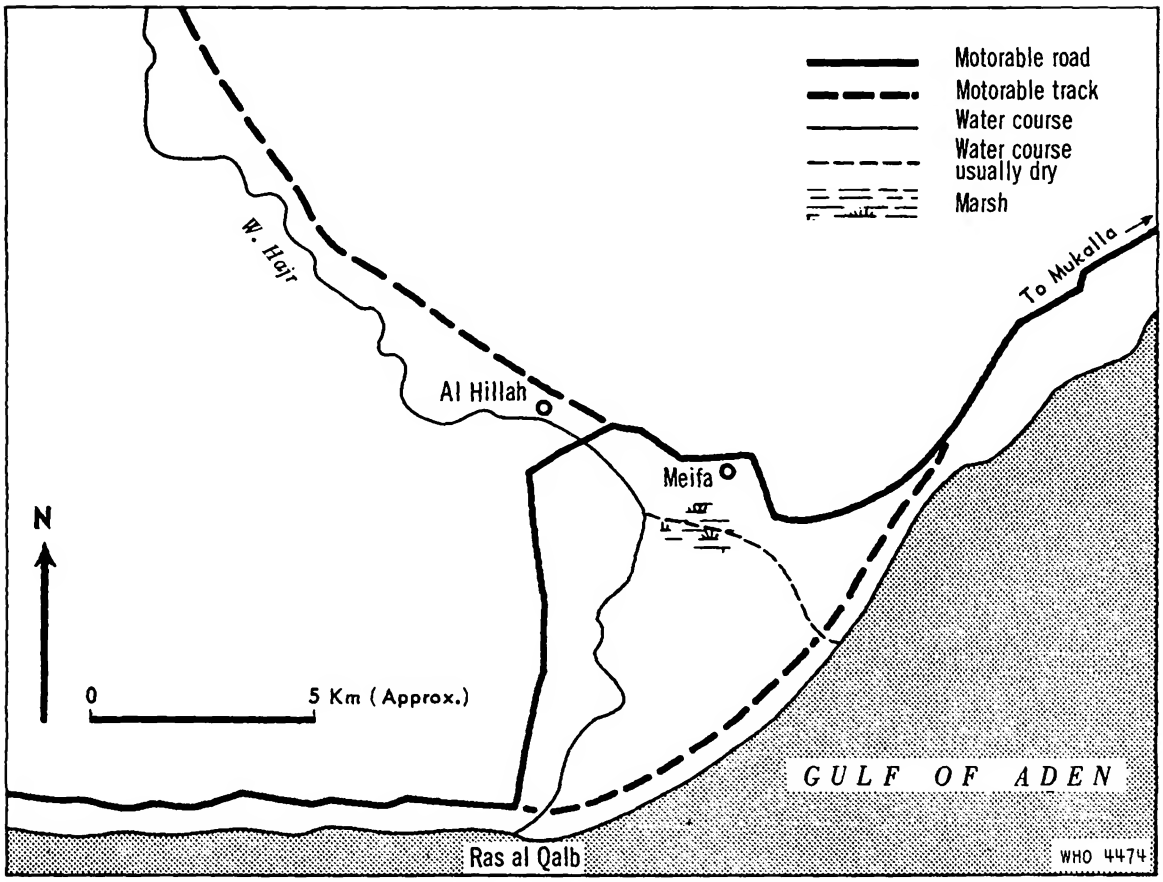


FIG. 8

MUKALLA

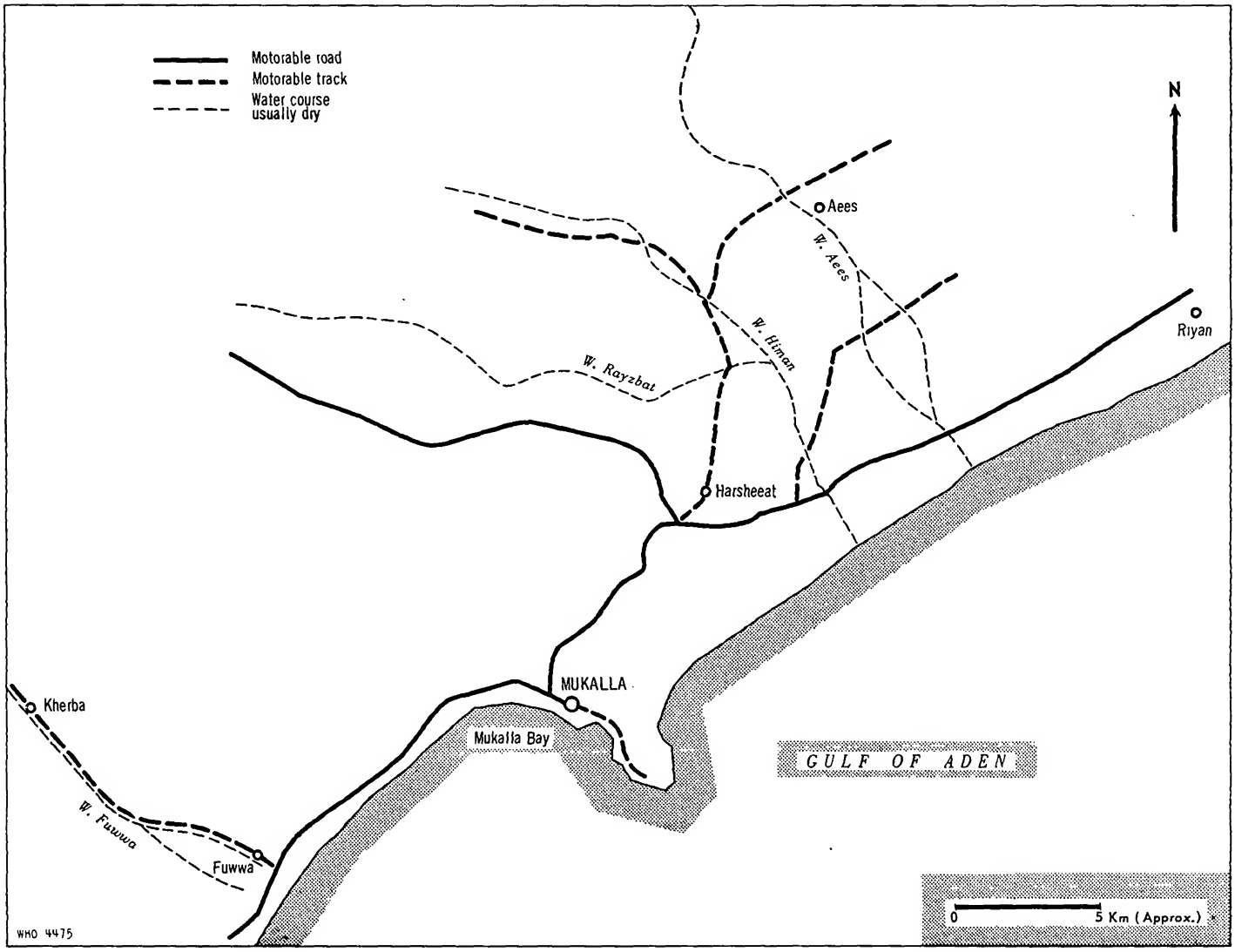
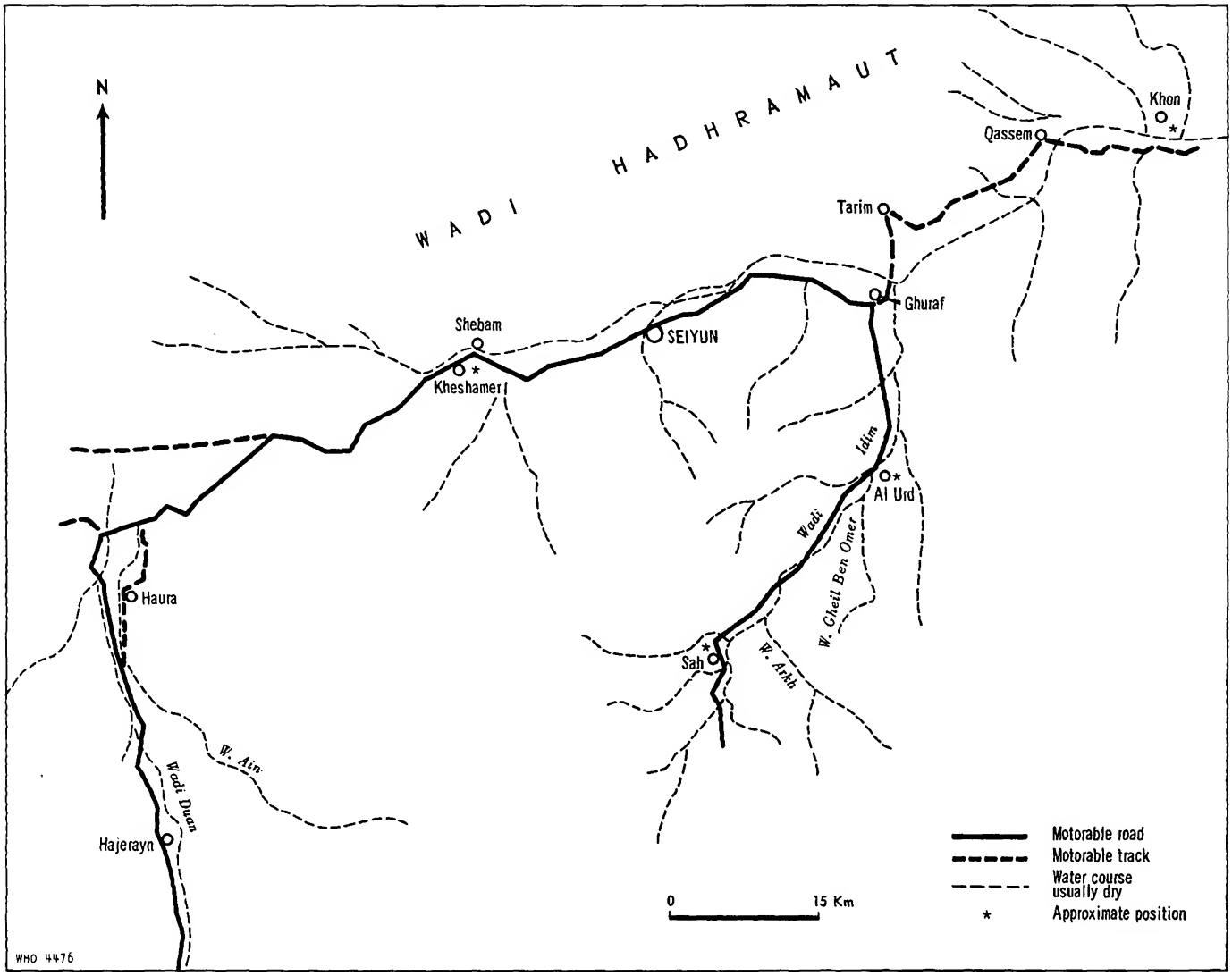


FIG. 9

WADI HADHRAMAUT



THE CLIMATE OF ADEN

(From information supplied to the Health Department by the Royal Air Force)

Aden (over six years)								Riyan (over six years)						
Month	Temperature mean daily maximum		Temperature mean daily minimum		Humidity %		Average monthly rainfall	Temperature mean daily maximum		Temperature mean daily minimum		Humidity %		Average monthly rainfall
	(F)	(C)	(F)	(C)	0300 hours	1500 hours	mm	(F)	(C)	(F)	(C)	0300 hours	1500 hours	mm
Jan.	82	28	72	22	78	63	5.0	82	28	67	19	80	62	7.6
Feb.	83	28	73	23	85	79	2.5	83	28	68	20	77	61	2.5
Mar.	86	30	76	24	82	66	5.0	85	29	70	21	86	64	91.4
Apr.	89	32	77	25	83	66	2.5	88	31	74	23	87	68	5.0
May	93	34	81	27	83	66	2.5	91	33	77	25	88	70	2.5
Jun.	98	37	84	29	76	51	2.5	94	34	80	27	86	67	2.5
Jul.	97	36	83	28	76	49	5.0	92	33	77	25	84	65	2.5
Aug.	96	36	82	28	78	50	2.5	91	33	76	24	86	65	2.5
Sept.	96	36	83	28	78	56	2.5	90	32	78	26	89	72	2.5
Oct.	91	33	76	24	77	58	2.5	88	31	72	22	87	68	2.5
Nov.	86	30	73	23	77	61	2.5	86	30	69	21	82	62	17.8
Dec.	83	28	73	23	76	62	5.0	83	28	68	20	79	60	7.6
					Yearly average		40.0					Yearly average		146.9

THE CLIMATE OF ADEN (continued)

Month	Mukeiras (over four years)					Dhala (over five years)					Beihan (over three years)				
	Temperature mean daily maximum		Temperature mean daily minimum		Average rainfall	Temperature mean daily maximum		Temperature mean daily minimum		Average rainfall	Temperature mean daily maximum		Temperature mean daily minimum		Average rainfall
	(F)	(C)	(F)	(C)	mm	(F)	(C)	(F)	(C)	mm	(F)	(C)	(F)	(C)	mm
Jan.	63.5	17	38.1	3	1.0	76.7	25	51.0	11	14.3	79.7	26	47.0	8	5.16
Feb.	66.5	19	42.1	6	8.6	76.7	25	52.5	11	7.8	85.7	30	51.8	11	9.76
Mar.	69.9	21	45.1	7	6.9	80.5	27	53.9	12	10.1	91.2	33	58.7	15	12.3
Apr.	72.3	22	49.2	10	32.7	84.1	29	58.7	15	16.6	93.3	34	62.5	17	57.96
May	77.3	25	51.8	11	13.3	89.2	32	62.7	17	42.3	96.4	36	64.8	18	3.13
Jun.	80.4	27	55.1	13	2.7	92.3	34	66.0	19	13.4	99.6	38	66.5	19	1.66
Jul.	78.3	26	58.8	15	46.6	91.5	33	65.2	18	105.9	99.3	37	66.8	19	7.16
Aug.	75.3	24	57.4	14	94.7	88.0	31	62.1	17	112.7	101.6	39	70.2	21	55.8
Sept.	75.4	24	53.3	12	30.8	87.1	31	61.0	16	41.0	95.9	35	64.6	18	-
Oct.	72.9	23	46.6	8	0.6	87.2	31	55.5	13	6.3	90.3	32	55.2	13	-
Nov.	67.8	20	43.0	6	0	81.6	28	55.1	13	6.2	85.0	29	49.3	10	-
Dec.	65.5	19	40.1	5	0	77.4	25	50.6	10	0	77.8	25	45.2	7	-
		Yearly average			237.0		Yearly average			376.6		Yearly average			152.93

HEALTH SERVICES AND MALARIA ENDEMICITY IN THE FEDERATION

State	Population	Number of health units	Population (administered) per health unit	Malaria endemicity*
WAP				
Lahej	39 000 (State estimate 90 000)	10	3 900	Continuous transmission at Kersh, Tor el Baha and in parts of cotton growing area. Intermittent transmission elsewhere.
Aqrabi	5 000	1	5 000	Intermittent transmission.
Haushabi	3 000	1	1 500	Continuous transmission.
Alawi	1 500	1	750	Intermittent transmission.
Dhala	64 000	2	32 000	Continuous transmission in Figara, Ahmedi and parts of Azariq. No transmission on J. Jehaf. Intermittent transmission the rest.
Shaiba	5 500	1	5 500	Intermittent transmission.
Radfan & Halmein	38 700	-	-	Intermittent transmission.
Muflahi	3 000	2	1 500	Intermittent transmission.
Lower Yafai	132 000 (another estimate 80 000)	5	2 000	Administered area (North Abyan) continuous transmission. Probably intermittent transmission in the rest.
Upper Yafai	11 700	-	-	Intermittent transmission.
Fadhli	55 000	5	11 000	Mainly intermittent transmission.
Audhali	15 000	2	7 500	Some continuous transmission near Lodar, probably no transmission in Mukeiras. The rest intermittent.

HEALTH SERVICES AND MALARIA ENDEMICITY IN THE FEDERATION (continued)

State	Population	Number of health units	Population (administered) per health unit	Malaria endemicity*
Dathina	13 000	1	13 000	Intermittent transmission.
Beihan	28 000	3	9 300	Intermittent transmission in south, probably no transmission in north.
Upper Aulaqi Sultanate	19 000	1	10 000	
Upper Aulaqi Sheikhdom	12 000	1	6 000	Transmission in Yeshbum. Northern part probably non-malarious.
Lower Aulaqi Sultanate	14 000	2	5 000	Intermittent transmission.

* The estimate of malarial endemicity is made on the basis of Medical Department reports, and the results of previous surveys. Where the present survey has confirmed these results is indicated in the text of this report.

HEALTH SERVICES AND MALARIA ENDEMICITY IN THE EASTERN ADEN PROTECTORATE

State	Population	Number of health units	Population (administered) per health unit	Malaria endemicity
EAP				
Wahidi	47 000	5	9 400	Continuous transmission in Wadi Meifa'a. Intermittent transmission the rest.
Quaiti	281 000			
1. West Province (Haura)	25 000	2	12 500	Most of this area is included in section on malaria in Wadi Hadhramaut, but it includes desert areas where there is probably no transmission.
2. Duan Province	65 000	4	16 100	
3. Hadj Province	15 000	3	5 000	Permanent water with continuous malaria transmission.
4. Shibam Province	26 000	4	6 500	Mainly included in section on Wadi Hadhramaut but also desert areas.
5. Shihr Province	70 000	5	14 000	Contains some areas with predictable seasonal malaria, some subject to epidemics in bad years. Some coastal towns have no record of malaria transmission.
6. Mukalla Province	80 000	2	40 000 (Mainly urban area served by a hospital)	
Kathiri	73 000	6	12 100	(See section on Malaria in Wadi Hadhramaut.)
Mahara (including Socotra)	75 000	2 special units		Malaria is known to be endemic in Socotra. No information for rest of State.

APPENDIX 3

MALARIA INCIDENCE AS REPORTED BY HEALTH ASSISTANTS IN 1961

WEST ADEN PROTECTORATE

	Total new cases all diseases	New malaria cases	Proportional morbidity
(1) Tor el Baha area			
Shaab	2 954	470	15.9%
Tor el Baha	5 895	683	11.6%
Am Shatt	2 376	281	11.8%
Ras el Ara	3 068	342	11.1%
	14 293	1 776	12.2%
(2) Lahej-Dhala			
Dar-Sad	6 346	460	7.2%
Wahat	2 771	235	8.5%
Lahej (hospital)	28 814	1 024	3.6%
Shakka	3 294	388	11.8%
Kersh	1 869	280	15.0%
Museimir	10 189	2 540	24.7%
El Qasha	1 588	129	8.1%
Dhala		Figures not available	
J. Jehaf	5 009	1 112	22.2%
	59 880	6 168	10.2%
(3) More isolated health units in the area			
Challa	5 096	477	9.5%
J. Hareer	6 178	197	3.2%
Awabil	3 750	230	6.1%
Daram Farsha	3 632	649	17.9%
	18 656	1 553	8.7%

Appendix 3

WEST ADEN PROTECTORATE (continued)

	Total new cases all diseases	New malaria cases	Proportional morbidity
(4) Abyan			
Bateis	4 781	197	4.1%
Huen	4 981	131	2.6%
Gaar	10 496	416	3.9%
Makhzan (hospital)	17 194	386	2.25%
El Kod	7 494	233	3.1%
Der Gag	2 687	104	3.8%
Zingebar	11 913	90	0.75%
	59 546	1 557	2.6%
(5) Other health units - WAP East of Abyan			
Shuqra	2 163	195	9.0%
Amwadhia	2 405	129	5.4%
Am Sawad	2 495	234	9.8%
Lodar	13 145	311	2.4%
Mukeiras	4 988	198	4.0%
Mukeiras (mission)	3 373	202	5.9%
Mudia	7 507	17	0.22%
Beihan (health assistant)*	2 456	390	15.8%
Beihan (mission)	3 048	55	1.1%
Negub	2 717	56	2.5%
Said	2 941	77	2.6%
Mahfid	4 171	275	6.6%
Ahwar	3 672	59	1.6%
	55 081	2 198	3.9%

* The figures for malaria from the health assistant Beihan apparently refer mainly to the villages in the wadis south of Beihan.

Appendix 3

EAST ADEN PROTECTORATE

	Total new cases all diseases	New malaria cases	Proportional morbidity
(1) Coastal area			
Mukalla hospital	17 055	138	0.8%
Shihr hospital	7 790	188	2.0%
Hami	1 495	54	3.6%
Dis al Sharqia	587	45	7.5%
Reidat Abdul Wadud	562	2	0.3%
	27 489	427	1.5%
(2) Wadi Hajr area			
Sidara (figures for six months only)	1 416	564	39.0%
Jol Bahawa	1 145	71	6.1%
Meifa Hajr	1 560	146	9.3%
	4 121	781	18.9%
(3) Wadi Duan area			
Duan hospital	4 078	19	0.5%
Subeikh	1 706	28	1.8%
W. Amd	3 741	7	0.1%
Haura	842	7	0.8%
Sahwa	438	21	4.5%
	10 805	82	0.8%

Appendix 3

EAST ADEN PROTECTORATE (continued)

	Total new cases all diseases	New malaria cases	Proportional morbidity
(4) Wadi Hadhramaut area - (Those marked K = Kathiri; Q = Qaiti)			
Qatn (Q)	1 402	49	3.5%
Shibam hospital (Q)	5 415	247	5.0%
Hauta (K)	4 164	91	2.0%
Wadi Bin Ali (K)	2 738	69	2.8%
Seiyun hospital (K)	9 766	263	2.6%
Tarim (K)	3 493	146	4.1%
Qassem (Q)	1 184	72	6.0%
	28 162	937	3.3%
(5) Special areas			
El Abr (Q)	3 471	10	0.3% Desert
Sah (K)	1 688	330	19.0%) East Road
Gheil Bin Yomein (K)	365	16	4.5%) Hadhramaut
Reidah el Maara (Q)	1 058	14	1.1%) to Mukalla
Gheil Ba Wazir	8 962	66	0.7%)
Hadibu (Socotra)	454	52	11.0% Island
	15 998	488	3.0%
(6) Wahidi area			
Habban	2 490	299	12.0%
Hauta	2 152	467	21.5%
Meifa Wahidi	1 757	37	2.0%
Bir Ali	1 015	21	2.0%
Wadi Jardan	970	27	2.75%
	8 384	851	10.1%
		Total cases all diseases	302 415
		Total malaria cases	16 818

APPENDIX 4

ANTIMALARIAL WORK IN ABYAN

Soon after the end of the Second World War, the Abyan Cotton Board was set up to develop the Abyan district by improving the irrigation of the area. Up to the end of 1962, about 40 000 acres (1600 hectares) had been brought under cultivation.

During the period of the construction there was considerable morbidity, and even mortality, from malaria amongst the labourers, and antimosquito measures were undertaken, paid for by the Board.

The method chosen was larviciding with 5% DDT in malariol; the operation was put in the hands of a health assistant, with a staff of eight spraymen, eight labourers and eight donkeys.

The operation starting in 1949 was carried out very efficiently: each sprayman was made responsible for a geographical area and was subjected to rigid discipline. Assessment was by search for larvae, either anopheline or culicine. No search for adults was made. Finding larvae in the area for which a sprayman was responsible was dealt with by fines on the first two occasions and for the third offence dismissal. The health assistant reported that during the five years from 1949 to 1954 when larviciding was carried out, many spraymen were dismissed but there were always others ready to take their place, usually by promotion of intelligent labourers. Long hours were worked, from seven to twelve in the morning, and from one to six in the afternoon. About 540 drums of larvicide were used a year.

It appears that these operations were extremely successful, malaria transmission seems to have been stopped and it was very difficult to find any mosquitos, either culicine or anopheline in the district.

The disadvantage of the scheme was its cost - it was said to be about £ 10 000 (US$ 28 000) a year. The larvicide was apparently Malariol HS costing about £ 8000 (US$ 22 400) a year, and the labour and transport about £ 2000 (US$ 5600).

In 1954, in order to reduce the cost, a change was made to residual house-spraying with BHC. The objective of the operation was to spray each house in the district four times a year. This was seldom, if ever, accomplished through shortage of supply of insecticide. During 1961 the whole district was sprayed once, and about a third of it twice. It is not clear what dosage of insecticide was aimed at.

Appendix 4

The operations are in the hands of a health assistant, working under the direction of the senior medical officer, Makhzan, and the spraying is done by the mobile sanitary squad of about five labourers. Although operations are not carried out with the perfection required for malaria eradication, there seems no doubt that good control could be achieved with only a few modifications of the organization, provided that enough insecticide was available.

Medical opinion in Abyan suggests that the amount of malaria increased after the larviciding stopped, but is now at a lower level again. It is suggested that this is due to a reduction of anopheline breeding places consequent on the more efficient use of water for irrigation. This reduction has not been associated with an increase in the extent of residual spraying. Comparison of health unit attendances reported as malaria does not show any marked change in 1961 and 1962.

APPENDIX 5

SPLEEN RATES
ADEN PROTECTORATES

	Rate	Numbers	Observer	Date of observation	Notes
Abyan					
Bateis	60%	50/83	Dr Hunter	29/9/62	Primary school children between ages 6-15 years
Ruah	25%	12/48	"	30/9/62	
Makhzan	16%	14/88	"	30/9/62	
Museimir (Fadhli)	0%	1/58	"	1/10/62	
El Kod	8%	10/127	"	2/10/62	
Der Gag	5%	8/121	"	3/10/62	
Lahej area					
Shaqaa	33%	11/44	Dr Sadaqa	16/9/62	
Khudad	37%	13/35	"	16/9/62	
Tor el Baha	15%	28/188	Dr Hunter	10/62	
Lahej	1%	3/210	Dr Sadaqa	9/62	
Kersh	24%		Health assistant	9/62	
Haushabi					
Museimir	84%	(42/50)	Dr Hunter	31/10/61	
Beihan					
Ulya	0%	1/162	Dr Hunter	11/62	
Negub	0%	0/36	"	11/62	
Amiri					
Dhala	11%	23/202	"	28/11/61	
Figara	70%	28/41	Reliable health assistant	10/62	
Azariq	20%	9/45	Dr Hunter	10/62	
Geleela	10%	5/49	Reliable health assistant	10/62	

Appendix 5

SPLEEN RATES
ADEN PROTECTORATES (continued)

	Rate	Numbers	Observer	Date of observation	Notes
Aulaqi					
Said	1%	1/85	Dr Hunter	8/12/61.	
Yeshbum	3%	6/183	"	9/12/61	
Eastern Aden Protectorate					
Mukalla	.72%	13/1807	Dr Hussein	1962	
Dis	1%	3/285	Dr Hunter	5/1962	
Wadi Duan (Khoreiba)	1.2%	3/125	"	5/1962	
Wadi Hajer (Jol Ba Howa)	45%	20/45	"	5/1962	

The attached map shows spleen rates taken by one of us (M. J. Colbourne) in schools in Abyan, December 1962.

APPENDIX 6

SPLEEN AND PARASITE RATES

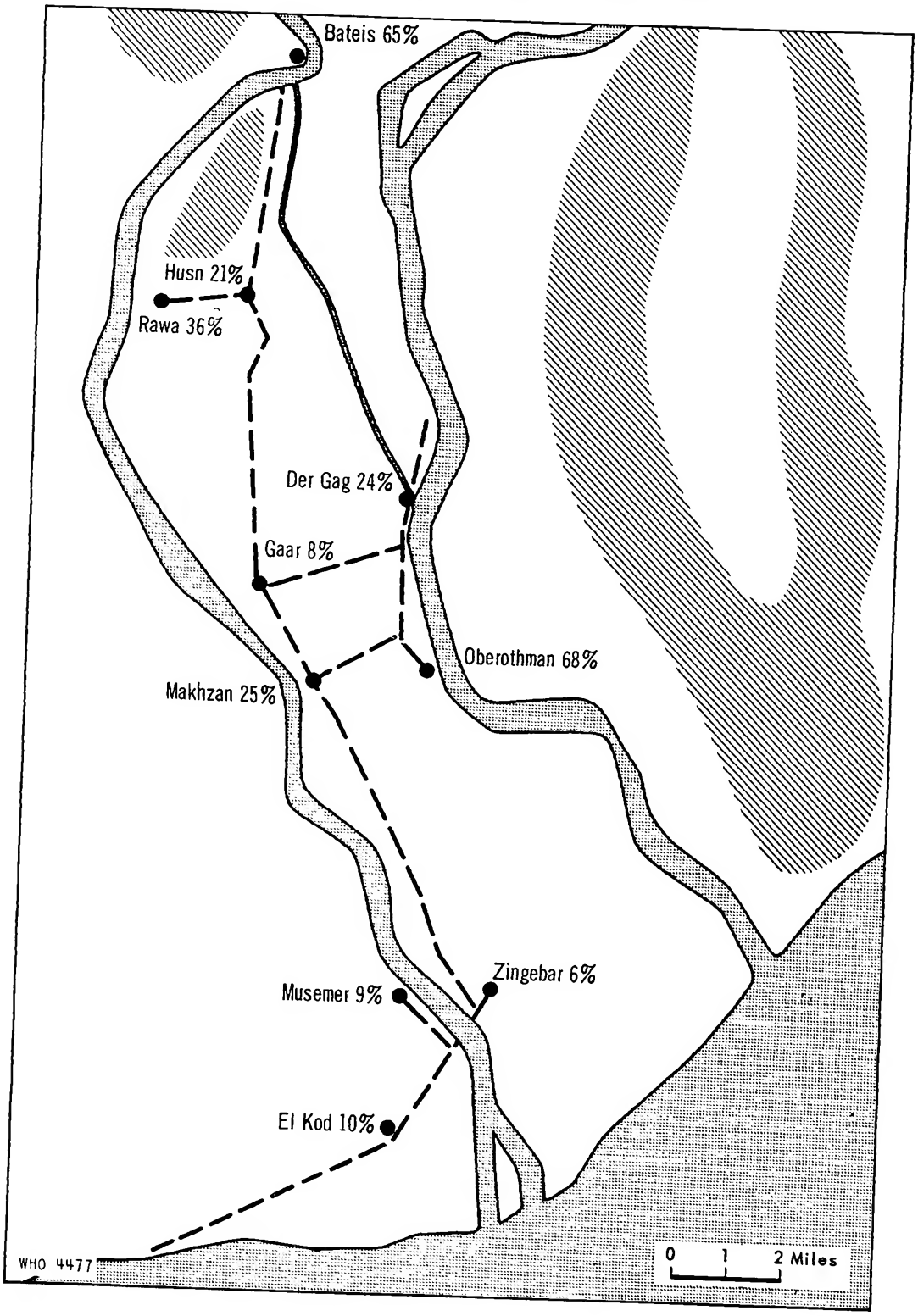
OCTOBER-DECEMBER, 1962

Area place	Age-group	Spleen		Parasite	
		No. examined	Rate	No. examined	Rate
Abyan[1]					
Bateis (clinic)	2-9			13 (6)	46.1%
	1/2-30			29 (13)	44.7%
Bateis (school)	2-9	42 (27)	64.2%	42 (11)	26.1%
	6-15	90 (56)	62.2%	90 (24)	26.6%
Der Gag	2-9	31 (6)	19.3%		
	6-12	54 (13)	24.1%		
El Kod	2-9	72 (7)	9.7%		
	5-11	79 (8)	10.1%		
Gaar	2-9	91 (9)	9.8%		
	6-10	95 (9)	9.4%		
Husn	2-9	73 (19)	26.0%		
	5-10	80 (22)	27.5%		
Makhzan	2-9	43 (10)	23.4%	43 (4)	9.3%
	6-15	96 (22)	22.9%	96 (4)	4.1%
Musemer	2-9	25 (3)	12.0%		
	7-12	32 (3)	9.3%		
Oberothman	2-9	17 (12)	70.5%		
	6-12	39 (27)	69.2%		
Rawa	2-9	38 (14)	36.8%		
	5-10	44 (16)	36.3%		
Zingebar	2-9	46 (3)	6.5%		
	6-11	53 (3)	5.6%		
Lahej					
Khodad	2-9	30 (22)	73.3%	30 (5)	16.6%
	5-12	44 (27)	61.3%	44 (6)	13.6%
Norbet Aiyed	2-9	111 (4)	3.6%	82 (1)	1.2%
	5-16	151 (5)	3.3%	89 (3)	3.3%

[1] The attached map shows spleen rates taken by one of us (M.J.Colbourne) in schools in December 1962.

FIG. 10

ABYAN. Spleen Rates December 1962



Appendix 6

SPLEEN AND PARASITE RATES

OCTOBER-DECEMBER, 1962 (continued)

Area place	Age-group	Spleen		Parasite	
		No. examined	Rate	No. examined	Rate
Dhala					
Azariq	2-9	27 (8)	29.6%	27 (4)	14.8%
	7-12	42 (14)	33.3%	42 (5)	11.9%
Zubeid	2-9	26 (0)	-	26 (1)	3.8%
	7-12	51 (5)	9.8%	51 (2)	3.9%
Lodar					
Amshaa	2-9	61 (2)	3.2%	36 (1)	2.7%
	6-11	80 (2)	2.5%	40 (1)	2.5%
Amwadhia	2-9	12	-	12 (1)	8.3%
	7-15	73 (2)	2.7%	42 (1)	2.3%
Megal	2-9	15 (3)	20.0%	15 (1)	6.6%
	1-60	23 (4)	17.7%	23 (2)	8.6%
Mukalla					
Fuwwa	2-9	44 (5)	11.3%	44 (4)	9.9%
	8-10	45 (6)	13.3%	45 (4)	8.9%
Meifa Hajr	2-9	24 (6)	25.0%	24 (3)	12.5%
	7-16	48 (12)	25.0%	48 (6)	12.5%
Meihan El Museid	5-12	10 (1)	10.0%	10	-
Wadi Hadhramaut					
Hajerayn	2-9	45 (1)	2.2%	40	-
	6-13	59 (1)	1.6%		
Haura	2-9	46 (1)	2.1%	33	-
	6-12	53 (1)	1.8%	39	-

Appendix 6

SPLEEN AND PARASITE RATES

OCTOBER-DECEMBER, 1962 (continued)

Area place	Age-group	Spleen		Parasite	
		No. examined	Rate	No. examined	Rate
Wadi Hadhramaut (continued)					
Kheshamer	2-9	12 (0)	-		
	7-16	68 (1)	1.4%	21	-
Qassem	2-9	36 (0)	-	23	-
	7-13	56 (1)	1.7%	40	-
Sah	2-9	58 (11)	18.9%	40 (4)	10.0%
	4-10	61 (12)	19.6%	43 (4)	9.3%
Yemeni immigrants	Never visited Aden before:			18 (2)	
	visited more than 1 year before:			8	
	visited less than 1 year before: (including drivers & their mates)			80 (2)	
				106 (4)	3.7%
Socotra	Boys	4 (2)	50.0%	4 (1)	25.0%

Figures in brackets indicate those found positive.

SUSCEPTIBILITY TESTS ON A. GAMBIAE FROM ABYAN

Date	Insecticide and dosage	Condition of mosquitos	No. mosquitos	Test	% mortality	No. mosquitos	Control	% mortality
				No. dead after 24 hours			No. dead after 24 hours	
1.11.62	Dieldrin 4% 1 hour exp.	Reared from larvae	12 ♀	12	100%	10 ♀	2	20%
2.11.62	Dieldrin 0.2%	Reared from larvae	13 ♀	13	100%	12 ♀	8	75%
3.11.62	Dieldrin 0.2% 1 hour exp.	Wild-caught unfed	9 ♀	9	100%	8 ♀	5	62%
4.11.62	Dieldrin 0.2% 1 hour exp.	Wild-caught fed	14 ♀	14	100%	12 ♀	9	75%
26.11.62	Dieldrin 0.4% 1 hour exp.	Reared from larvae	18 ♀	18	100%	16 ♀	5	31%
27.11.62	Dieldrin 0.2% 1 hour exp.	Reared from larvae	21 ♀	21	100%	15 ♀	3	20%
17.12.62	Dieldrin 0.2% 1 hour exp.	Wild-caught fed	15 ♀	15	100%	15 ♀	13	86%
1. 1.63	Dieldrin 0.4% 1 hour exp.	Reared in lab. unfed	4 ♂ 35 ♀	4 35	)	Carried out in Ross Institute, London		
			39	39	100%)			

SUSCEPTIBILITY TESTS ON A. GAMBIAE FROM ABYAN (continued)

Date	Insecticide and dosage	Condition of mosquitos	No. mosquitos	Test: No. dead after 24 hours	Test: % mortality	No. mosquitos	Control: No. dead after 24 hours	Control: % mortality
*1. 1.63	DDT 4.0%	Reared in lab.	158 ♂	153	97%			
25. 1.63	1 hour exp.	unfed	145 ♀	100	69%			
			303	253	83%			
5. 2.63	Offspring of survivors of (*) mated with unselected males					Carried out in Ross Institute, London.		
	DDT 4.0%	unfed	87 ♂	86	99%			
	1 hour exp.		82 ♀	76	93%			
			169	162	96%			
	DDT 4.0%	unfed	38 ♂	38				
	2 hours exp.		30 ♀	30				
			68	68	100%			

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